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ANNOUNCEMENT

We regret that owing to circumstances over which the Publications Committee have no control the appearance of this and the September number has been delayed.

CONTENTS

The Winter School of Soil Science ..... by G. W. Leeper 153

Note on Tropical Fruit, Vegetable and Poultry Production in Northern Australia, 1940-45 ..... by N. A. M. Kjar 157

Some Modern Trends in the Dairying Industry ..... by V. R. McDonald 166

The Present Status of D.D.T. as an Insecticide ..... by G. A. H. Helson and D. F. Waterhouse 172

Production of Lactic Acid. I. From Whey ..... by R. J. Swaby 179

Production of Lactic Acid. II. From Wheat Starch ..... by R. J. Swaby 185

Technical Notes—

Reliability of Rain in Australia as Compared with the Rest of the World ..... by G. W. Leeper 188

Diapause in *Scelio Chortoicetes* Frogg. (Scelionidæ), a Parasite of the Eggs of *Austroicetes Cruciata* Sauss. ..... by L. C. Birch 189

Influence of Yeast Extract on *Lactobacillus bulgaricus*, Incubated at Various Temperatures ..... by R. J. Swaby 191

Tension of Water in a Sandy Soil at Field Capacity ..... by T. J. Marshall 192

Host Parasite Relations in Pink Rot of Potato ..... by N. H. White 195

The Australian Institute of Agricultural Science 198

Current Notes and News 200

Book Reviews 202

Personal Notes 204

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VOL. 11, No. 4 DECEMBER, 1945

The Winter School of Soil Science

Conferences play an essential part in the advance of science. Discussing one's subject with fellow-workers helps to clarify it to a degree that would never be otherwise achieved, and with the scattered nature of our scientific institutes, the need for periodical meetings is particularly great.

The most valuable scientific conference is one in which a fairly small field is to be covered, and the first Winter School of Soil Science, held at the Waite Institute in 1939, was a landmark in the development of the subject in Australia. This year gave us the first opportunity since the war began for a similar Australia-wide conference, and the second Winter School of Soil Science was held, again at the Waite Institute, from 20th to 30th August. There were several representatives from each State and one from New Zealand. These included a wide range of interests ; besides those directly concerned in soil survey and soil chemistry there were many agriculturists, foresters, irrigationists and engineers. There were 120 delegates, and the attendance at some meetings reached 140. The programme comprised eight and a half days of meetings and one full-day excursion for which five pits had been dug to illustrate major soil profiles between Adelaide and Roseworthy. The visitors owe a debt of gratitude to the responsible bodies—C.S.I.R., Adelaide University, and Waite Institute—for their hospitality, and to the organizers for their hard work.

This conference had two purposes : firstly, to introduce some of its members to the physics and chemistry of soil and to the methods and language of soil survey ; secondly, to give the specialists in soil science, both surveyors and research workers, an opportunity to exchange ideas. Accordingly, the first six half-day sessions were aimed at instruction, and the remainder at discussion of controversial matters. While there are merits in this combination of the two purposes, of refresher course for non-specialists and of discussions among specialists, there will also be a need in the future for separate meetings of the two kinds of workers. It should then be easier to have fewer speakers on the programme and so to allow ample time for discussion.

The chief distinction in subject-matter between this conference and its predecessor was that while the first dealt analytically with the physics and chemistry of soils, this one dealt rather with the whole profile, as observed to a depth of four feet or more. This shift of emphasis is no doubt due to the fact that soil surveying has greatly expanded in recent years, and the soil surveyor is interested in classifying and mapping soils according to their profiles, in speculating about how they were formed, and in relating his soil types to land use. The word *pedology* is sometimes used for

this part of the study of soil, and the following paragraphs summarize the main pedological problems that were discussed. It should be mentioned, however, that the use of analysis in determining the need for fertilizers was not left out altogether ; one session was given on spectrographic analysis and in another we had an account of the successful use of dilute-acid extraction for determining the need for fertilizers for sugarcane.

Pedology.

Soil science is immature, and is still in a confused state both in its terminology and in its schemes of classification. There is need for a great deal of discussion in both these fields. For example, what is *texture* ? Soil surveyors and farmers (some farmers, at least) call a soil a sandy loam or a clay according to what it feels like both when it is moist and when it is dry. (A sandy loam is friable without being loose like a sand ; and its sand grains can be distinctly felt.) This is " field texture ". But one can also take the same sample of soil and find the composition of its inorganic matter in terms of particles of up to 0·002, 0·02, 0·2 and 2 millimetres in diameter, and then say that if its mechanical composition is close to a certain formula for relative amounts of these fractions it shall be called a sandy loam. This " laboratory texture " is evidently different from " field texture ". The same soil might of course be called a sandy loam by the surveyor and by the analyst, but not necessarily so. We have then to decide what " sandy loam " is to mean. This was discussed at great length, and the prevailing view seemed to be that it should mean what the soil feels like. Probably the reason why this confusion ever arose is that field texture is a subtle personal impression ; the classes of texture have to be communicated from expert to novice from one generation to another. The laboratory measurement by contrast appears to be objective, and hence its prestige, though it measures different properties.

Classification.

Problems of classification are particularly acute. The point was well made that we group soils together for three purposes : (1) for taxonomy, according to their characteristics ; (2) for mapping ; and (3) to study their interrelations, especially their mode of formation. These three purposes have often been confused, to the bewilderment not only of the specialist, but even more of the layman. The discussions at this conference were most useful for sorting out the tangle, and further discussions from time to time should complete the process.

(1) We group soils together in the following order of generalization :

Phase—Type—Series—Fasc—Group,

a sequence that has some analogy to the biological one :

Ecotype—Species—Genus—Family—Order.

The analogy should not be pushed too far ; for example, soils are capable of complete " interbreeding " at any level in the sequence. However, the *soil type* (Murray sand, Niemur clay) corresponds somewhat to a species, though some prefer to make the unit the *soil series*, which consists of two or more closely-related types (Barmera sand, Barmera sandy loam). Collections of soil series which resemble each other can be put together into a *fasc* (*fascis*=bundle). This useful word helps to solve the difficulty that we are continually accumulating more and more soil series with every survey, and the ordinary agricultural worker cannot be expected to be familiar with more than a few names among them. Incidentally, this word shows up our lack of good collective names in pedology, a lack that is curious in the language that has supplied the famous *gaggle*, *pride* and *covey*.

The last step is the hardest—namely, how to put different fascs together to form the Great Soil Group, by which all the world's soils are to fit into about forty pigeon-holes labelled Chernozem, Red-brown Earth, and so on. We can fit our soils into

fascs within Australia, without consulting other countries ; but the Groups extend through the world, and we must either find an existing pigeonhole for our collections or create a new one. While classification into Groups came under discussion from time to time, it was clear that much more discussion was needed (or perhaps, as some suggested, more field work was needed) before this stage could begin to be satisfactory. Apart from other troubles, there is the difficulty of deciding what many of the overseas workers mean before we use their terms. Confusion of terms was most evident in a session on " Laterite ", when the main speaker was concerned with ironstone as gravel or massive rock, but a subsequent speaker used the same term, laterite, to mean a deep red soil. It is no wonder that the outsider finds pedology difficult.

The *phase* is the smallest subdivision in the sequence and members seemed agreed as to its definition. A phase may be mapped where there is enough difference within a type to be of practical importance ; Benetook loam is tile-drained at four feet, but Benetook loam, gypseous phase, being more permeable in the deeper horizons, can be drained at six feet. It seems to be often a matter of personal taste whether a patch of somewhat different soil is mapped as a phase or elevated into a type. In fact, the unceasing struggle between lumpers and splitters is found in soil work as in biology.

(2) We also need devices for grouping different types or series together for mapping. This leads to the *complex* (two or more types closely interwoven), *catena* (a sequence of types from hilltop through valley and back to hilltop, the same sequence constantly repeated in each successive hill and valley) and *association* (a somewhat similar idea of several soil types coming together in one kind of landscape). The last step, of mapping a big area by putting catenas or associations together to form a *soil zone*, is again difficult. It would be nice if all, or nearly all, the soils within a compact area belonged to one group. Similar associations would then be united, ignoring perhaps a few low-lying types which did not belong to the dominant Group. But as our Western Australian members reminded us, this is not always so, and within any district we may have several Groups represented. When this happens, the map can best be divided according to the prevalent pattern of the mixture of Groups, and Dr. Teakle's classification of the soils of Western Australia, in which Regions rather than uniform Zones are marked, is a contribution on a grand scale to set beside Professor Prescott's work on Australia.

(3) *Mode of Formation.*

The main subject under this heading was the origin of the so-called lateritic country which is widespread in Australia and which is characterized by poor sandy soils, with ironstone gravel on the tops of ridges. There is now much support overseas for the view that ironstone gravel is often the residue of a very wet climate of Tertiary times, and persists today simply because of its resistance to weathering.

Land Use.

While a soil map is essential for the agricultural knowledge of a district, the work of the soil surveyor becomes far more interesting if he can see some practical result follow from his action in marking a boundary between type A and type B, which may differ only in minor features. The soil map must be related to land use to make it worth while, and the best example of this is seen in irrigated orchards. For each soil type there are relations between slope, width of furrow, length of run, and rate of applying water, from which a lay-out and method of application can be devised so as to ensure that just enough water, and nowhere too much, penetrates along the run. This use of soil maps in practice on the Murrumbidgee Irrigation Area was set out before the conference.

This use of a soil map relies on field experience. Attempts have also been made, especially in America, to apply surveys directly by allotting marks to a soil type for

each of its chief features, such as texture, slope, salinity and pH, and so reaching a final figure which allows types to be arranged in order of desirability. Such an application was discussed, but was not generally favoured; it is obviously difficult to draw up a scale of marks which can be universally true.

Erosion was the subject of one session. Erosion is intimately linked with land use and in some places is directly related to soil type; but emphasis is passing away from soil type to land use as the major feature in erosion, and the soil map may be used mostly because of the relation between soil type and land use. Several simple facts about the mechanism of erosion have been established experimentally in recent years; most of these facts emphasize the primary importance of cover in conservation.

The above account has dealt with the central themes of the conference—pedology and land use. Other subjects included rainfall variability and the teaching of soil science. A further new departure was the attention given to soil physics as applied to the engineer's problems in treating material for roads and earth dams. The common ground of science here between the agriculturist and the engineer is slight, but further advances in this subject might well lead eventually to a better understanding of agricultural problems.

A final comment seems to me most necessary. While fully appreciating the hard work put into their preparation, one must say that the presentation of many papers could have been greatly improved. Expounding one's own subject is a large problem, to which we scientists give far too little attention. There are techniques to be learned here, as much as in laboratory work, and we might well invite experts in these techniques to give us advice and criticism. I am sure that one piece of advice would be that no lecture should exceed an hour. Methods of illustration are also vitally important, and here we had a welcome example in some clear and bold diagrams which were offered by the contingent from Griffith and which could be easily seen from the back of the room—a test which we should surely make ourselves before inflicting a diagram or a lantern slide on an audience.

G. W. Leeper.

Notes on Tropical Fruit, Vegetable and Poultry Production in Northern Australia, 1940-1945

By

CAPT. N. A. M. KJAR*

Much has been written during recent years and very much more spoken by both military and civilian visitors about the post-war possibilities of the Northern Territory. Some have been worded in most optimistic terms, while others verge on the reverse. Between the two extremes, the average man in the street is not able to formulate a very clear mental picture of the actual position. The object of this article is firstly to present some facts about what has been actually achieved in some sections of agriculture by Army Farm A.A.S.C. units which have operated in Northern Territory since mid-1940, and secondly to record some conclusions drawn from this five years' practical experience.

With the progressive development of hostilities in the tropical regions of Australia and the islands to the north, there was during the years 1939-45 an ever-increasing demand for fresh vegetables, fruits and poultry products. Even in peace time, many of these areas were well known for deficiency diseases, the local market garden production plus the refrigerated supplies received at intervals from the south not being sufficient to supply the small local European populations.

Local Shortages Forced Army to Operate Farms.

Defence Department policy always has been, and still is, to purchase, wherever possible, food requirements through recognized civilian contractors. However, where abnormal factors operated, the Australian Army Service Corps, charged with the responsibility of feeding not only Army and R.A.A.F. personnel, but often shore-based R.A.N., U.S. forces and civilian workers, was forced to grow portion of its requirements locally.

In 1940 a neglected peanut farm of 107 acres at Adelaide River was purchased. From very small beginnings (2½ acres of vegetables in 1940) the project developed to 27 acres under crop in 1941, with production of 54 tons of vegetables; in 1942 to 33 acres with 72 tons of vegetables and fruits and 2,035 dozen eggs, all of first quality and distributed through Army Supply channels. Local control of the actual farm operations since inception and up to the present time has been the responsibility of W.O. (later Major) L. A. Campbell, a pre-war farmer with Queensland and Victorian experience. Paramount credit for the successes achieved must be given to his enthusiasm, energy and organizing ability plus the valuable technical assistance given (mid 1941-mid 1943) by Capt. H. K. C. Mair (previously Agricultural Superintendent at Darwin 1938-39).

When shipping to Darwin was fraught with considerable risk during the very difficult 1942 supply period, the production on the spot of the fresh article was of immeasurable value. In the wake of the agricultural success obtained from this one small farm at Adelaide River, the scheme was extended in 1943 to eight vegetable and fruit farms totalling 130 acres at Adelaide River, 20 acres at Hayes Creek (117

* Capt. Kjar was a pre-war member of the Department of Agriculture, Tasmania, and subsequent to writing this article resumed civilian duties as Senior Agricultural Officer, Launceston. From mid-1943 onwards, as Staff Captain, A.A.S.C. Farms, he was responsible for technical direction and personal supervision of the varied A.A.S.C. farm activities in Australia and New Guinea areas.

miles from Darwin), and 120 acres at Katherine (220 miles south of Darwin). The production in 1943 from these farms amounted to 1,019 tons of vegetables and fruits, 4,417 doz. eggs, 237 lb. dressed poultry and 120 lb. honey valued at a total of £91,315. During 1944, similar farms aggregating about 300 acres (including five acres at Coomallie Creek, 55 miles south of Darwin) were operated to produce 1,655 tons first quality fresh vegetables and fruits for distribution, as well as 53,831 doz. eggs, 3,024 lb. dressed poultry and 827 lb. honey. Plans for 1945 were modified with the reduction in demand, the production during the first eight months amounting to 229 tons of fruit and vegetables, 57,200 doz. eggs, 5,674 lb. dressed poultry, 2,129 lb. honey.

Experimental Unit Justified Itself.

During early 1944, a small experiment farm was commenced at Katherine to aid future agricultural success on the larger scale commercial operations. Sixteen acres of virgin bush typical of the river fringe land was developed by a small army unit under Lieut. J. Scott-Young. Advisory visits were made at the request of the Department of the Army in 1944 by C.S.I.R. officers Dr. Marshall (Soils) and E. M. Hutton (Vegetables), and in 1945 by G. A. Helson (Entomology). Practical advice frequently given by Dr. Prescott (Waite Research Institute) during the years 1940-45 regarding soil and water analyses was a most valuable contribution to the specialized knowledge required for success in these difficult areas.

Trials with vegetables and tobacco and entomological experiments were carried out in close association with C.S.I.R. officers, while experiments with tropical fruits pasture and cereal plots were based on Queensland Department of Agriculture recommendations. Systematic collections of insects and native pasture species were forwarded to C.S.I.R. for identification and record. Entomological trials included tests with D.D.T., 666 and synthetic cryolite in comparison with normal sprays and dusts for control of vegetable pests, D.D. on nematodes which had been proving troublesome, and with D.D.T. on tropical rice to observe any ill effects which might develop from the large-scale D.D.T. air sprays being used in Pacific Island malarial areas. Not only did this comprehensive experimental work prove of great value to the larger scale operations in 1944 and 1945, but the conclusions reached and extensive data collated by Army and C.S.I.R. personnel must be regarded as a valuable contribution to the agricultural knowledge of Northern Territory for civilian use in the post-war period.

"Wet" and "Dry" Season Limitations.

In the tropics there are no seasons such as summer, autumn, winter and spring. Everyone speaks only of "wet" and "dry". A keen understanding of this broad classification is necessary to appreciate the general limitations imposed by the climate. The "wet" (normally November-March inclusive), with its heavy rainfall, particularly during the last three months, high temperatures and humidity prevents normal cultivation or cropping except of special "rain-loving" plants. Many white people find this humid period very depressing, and claim that holidays in the south should be taken during the humid first three months of the year.

On the other hand, the "dry" season of seven months is most delightful, with consistently warm sunny days without clouds and relatively cool nights. Under irrigation a very wide range of plants can be grown successfully and mature with a rapidity that amazes those from colder areas. Imagine being able to obtain edible french beans in 34 days, cabbages and tomatoes in six weeks from transplanting! Major importance was placed by the Army on the production of those salad and leafy green vegetables and fruits, valuable for their high vitamin content and palatibility, to which Australian troops in civil life had been accustomed, and which could be grown in bulk and distributed to all messes. It was found that familiar and

popular items, such as tomatoes, cabbages, lettuce, cucumber, radish, silver beet, beetroot, french beans, sweet corn, marrows and pumpkins could be grown in most localities with minor modifications of technique and according to seasonal limitations.

During the " wet " a different position arose and only special semi-tropical or tropical species would thrive. These included cucurbits, tropical beans, such as sword, lab lab and snake, sweet potatoes and, to a limited extent, sweet corn, maize and chinese cabbage. Fruits included papaws, bananas, pineapples and mangoes. Future agricultural policy, however, must include more stress being placed on other tropical crops suitable for this particular " wet " season.

The Katherine is a strongly running river with banks 70 ft. high, the minimum flow in " dry " being recorded as 60 cu. secs. The water is of good quality. There appears to be possibilities of irrigation from this river if a natural reservoir 20 miles in the hills were dammed up. The Adelaide River has minimum " dry " flow of 20 cu. secs., and banks up to 40 ft. high. Quality of water is also good. Basic requirements were assessed at 5,000 gallons per day for every acre in crop. This works out at 1½ inches per acre per week, and permits of losses in transit and application. Salad crops appeared best with application every 24-48 hours, and others every 4-10 days, depending on weather, soil and stage of maturity.

Soil Types and Fertilisers Used.

Detailed analyses and informative data on Northern Territory soils are available in C.S.I.R. publications by Prescott. The most extensive farms were developed on areas fringing the Katherine and Adelaide Rivers. Brown sands of considerable depth were found at both Adelaide River and at Katherine. They were, however, limited in area, especially at Adelaide River, where the pockets of brown sand quickly verged into grey podzols. Because of this, and because of the less humid climate and the shorter wet, the Katherine River area was preferred. Daley River, which is really an extension of the Katherine, has similar soils, but road access was a difficulty. The grey podzolized soils away from the river frontage did not appeal for general agriculture, though they appeared to grow similar herbage and timber to the brown sandy soils.

Coomallie Creek, with a heavy alluvial loam, is a more typical garden soil which is limited to about seven-chain fringe along the creek, then gradually petering out to a soil type black with ironstone specks in the subsoil, indicative of bad drainage. Running water of very good quality is sufficient without any damming for 50 acres under crop at the one time. The Hayes Creek soil was of somewhat similar alluvial type, but not so rich in plant food. The water supply was obtained from a nearby spring which averaged 10,000 gallons per hour at end of " wet " to 4,000 gallons at end of " dry ", making 20 acres under crop the safe maximum.

Present recommendations are for an annual green manure crop during the " wet " of a legume such as Poona pea to be ploughed in before maturity as a means of retaining and building up the organic content so essential for all soils. With most vegetable crops grown after this green manure crop, 2 cwt. superphosphate and 4 cwt. blood and bone (or equivalent in superphosphate and sulphate of ammonia) at transplanting time is considered sufficient. Two or three side dressings of ½ cwt. sulphate of ammonia at intervals during growth may be necessary, depending on circumstances. These applications are preferred during actual growth as if applied at transplanting the loss on leaching under tropical irrigation is considerable. Necessity for potash has not yet been determined, but on the older cropped soils an application of ½-1 cwt. per acre would be warranted. The soil analyses did not indicate any lime deficiency and no knowledge of response or otherwise to lime applications is yet known. With fruit, heavier fertilizer applications along the lines recommended by the Queensland Department of Agriculture are preferred.

Notes on Vegetables: Varieties, Yields.

Quality of both fruit and vegetables was satisfactory and compared well with those grown elsewhere in Australia. The majority of the normal southern pests and diseases were experienced and routine control measures were necessary. It is understood that an article by G. A. Helson (C.S.I.R.) may shortly be published on this aspect.

Tomatoes.—Almost without exception tomato crops were very satisfactory, the following yields of first quality fruit being an indication: 1941, 15,538 lb.; 1942, 108,678 lb.; 1943, 838,386 lb.; 1944, 1,113,638 lb.

Although the 1944 crop averaged over eight tons per acre of first quality fruit distributed, an equal amount of overripe, inferior and "blossom end rot" types was left on the bushes. Production was obtained May-November inclusive, with peak July-early September. First fruits ripened 6-8 weeks after transplantation at four weeks. All varieties except Australian Large Red (1943 crop) gave good results, with Pearson outstanding for general purposes. Other suitable southern commercial varieties included Rutgers, Potentate, Pritchard, Devlin's Choice, Red Marhio, Burwood Prize, Earliana, Bonny Best, Chalk's Early Jewel, Ponderosa, while at the Experiment Farm, Grosse Lisse and several of the recent Pearson selections were very promising. Staking gave best results, but in view of the labour involved unstaked bush planting 6 ft. square had economic advantages. By special methods and use of well drained soils, it would be possible to extend the season much longer than May-November, but the yields might not be sufficiently economic. For home purposes, use of peppers over the off period as alternative to provide the vitamin C of tomato, has possibilities, but owing to its general unpopularity with troops was not used to any extent.

Cabbage.—Cabbages of excellent quality and up to 28 lb. weight (crop would average 6 lb. per head) were grown with little difficulty May-October with peak July-September. Age of normal crop at maturity was 6-9 weeks from transplanting. Succession was the variety preferred for field crops, although the seed showed much variation in type, which was accentuated by the damage caused by centre grub (*Helulla undalis* Fabr.) to the heart of seedlings after transplanting. Some of the variation may also be explainable by the plant being grown out of its normal temperate habitat. Golden Acre, Allhead and Allseasons also did very well.

Lettuce.—Successful lettuce production was limited in 1943 to certain favoured areas, but later improvement in technique and insistence on use of Imperial 847 indicated that during July, August and September very good quality hearts up to 4 lb. in weight could be obtained on most good quality soil under almost continuous spray irrigation and forced feeding. Transplanting was not successful and seed was sown in 12-inch rows. Good organic manuring prior to sowing, with side-dressing of sulphate of ammonia, produced hearts in 4-6 weeks equal to the best grown elsewhere. Mignonette, Neapolitan, New York and others gave good results, but not comparable in general satisfaction to Imperial 847.

Cucumbers.—All the year round production was obtained, but mildew became difficult to control during "wet" and in mid "dry". Early Fortune and Crystal Apple types were successful, with occasional failures. The mildew-resistant types, such as Cairns Atherton "Oriental", may be a solution.

Pumpkins, Marrows, Squashes, Rock and Water Melons.—All the year round production has been achieved with little difficulty, but yields have been light (three tons per acre average). Artificial fertilization was needed when bees were not present. Triamble and Turk's Cap were the best pumpkins. Rocky Ford and Hale's Best were good rock melons, while Hawkesbury Wilt Resistant and Kleckley's Sweet were preferred as water melons. Excellent quality melons up to 54 lb. weight have been grown, but "boiling" was common in hot moist periods. Mildew also reduced output on occasions.

Beans.—French dwarf types, Canadian Wonder and Brown Beauty preferred, yielded 100-150 bushels per acre in 1942 and 1943 under irrigation in early and mid " dry ". Growth was rapid and maturity obtained in 5-7 weeks. Quality of bean was fair to good, but plants were not really robust. *Dolichus lablab,* snake and sword beans gave very good results at all times, " wet " and in " dry " under irrigation. Lablab was also particularly useful as a quick low shelter belt.

Silver Beet.—This quick-growing crop gave very good results under irrigation, grown *in situ* or transplanted. Quality of leaves was very good, but owing to rapid wilting silver beet was not used to any extent by the Army. Fordhook Giant was considered the best variety, with Lucullus next.

Chinese Cabbage.—This plant, particularly valuable in the tropics owing to its rapid growth and outstanding vitamin content, should be used as a lettuce. It gave good results (5-8 weeks) under irrigation and in good soil, but in the " wet " was attacked by many pests, making constant spraying a necessity. Like silver beet, the rapid wilting of the leaves make it unsuitable for most Army conditions. Wong Bok, Pe Tsai and Chihli were all successful, without any marked preference being shown for the individual flavours.

Miscellaneous Crops.

Beetroot was a fair producer under good conditions such as those required for lettuce, but had a longer season –June to September. Quality was good and size medium. Best varieties were Detroit Red, Derwent Globe and Crosby's Egyptian. Limited success was obtained with carrots under special conditions, such as those for lettuce, with yields up to six tons per acre during July-September. Red-cored Chantenay and Geurande appeared the best types, but further experiment is needed. Small areas of onions in 1944-45 indicated that success with types such as Early Barletta, Imperial White Spanish and White Globe would be possible. Shallots gave very good results during the " dry " season under irrigation and for home gardens would be quite satisfactory. Radish were easily produced in the " dry " under irrigation. French Breakfast, Icicle, Long Scarlet were all good varieties. Quality was good and size large. Other successful crops on a small scale in the " dry " under irrigation were peas (Greenfeast and William Massey), rhubarb (grown as an annual from seed), kohl rabi, egg plant, peppers, cress, mustard. Sweet potatoes gave satisfactory yields in the " wet " and under irrigation in the " dry ".

Potatoes.—Potatoes from the southern States carry well in crates, so that there was no special need to grow them in the Northern Territory. With limited man-power, it was preferable to concentrate on crops high in vitamin C, such as greens and salads, which did not carry so well. However, in 1945 the Experiment Farm grew some trial lots from seed provided by C.S.I.R. These initial trials were most promising and indicated that quality tubers could be grown if needed in the future, but special varieties and methods would be necessary for success.

Tropical Fruits Successful and Quick Maturing.

Tropical fruits culture, being relatively rapid (nine months from transplanting), paid big dividends from an Army feeding point of view, enabling hospital patients and rest areas to be well supplied. It is not considered, however, that the local crops could normally compete in southern markets with Queensland areas, but there appears no reason why a local Darwin population could not be maintained all the year round by these tropical fruits if they were grown at the rate of half an acre per 100 head of population.

Bananas, Cavendish mainly, but Lady's Finger, William's Hybrid and Gros Michel also did well where freedom from winds could be secured. Pineapples, mostly MacGregor Rough Leaf and Ripleys, and papaws, local and Queensland strains, made good headway in suitable locations. There is much to be learnt about

these tropical plants under Northern Territory conditions. Heavier manuring appears necessary with special irrigation and cultivation practices, together with more information on the best time of transplanting. Mangoes planted many years ago by old residents also provided heavy crops of fruit, but they were not fully appreciated by many of the troops. Passionfruit vines (*Passiflora edulis*) grew very well, but failed to set fruit. Some custard apples made good growth, but at time of writing the trees were not of sufficient age to show results.

An area of five acres of citrus was successfully established at Adelaide River. The trees made remarkable growth all the year round ; perhaps 100 per cent. greater than in southern citrus areas. Varieties include : Mandarins, Emperor and Beauty of Glen Retreat ; Oranges, Washington Navel and Valencia ; Grapefruit, Marsh's Seedless and Thompson's Improved ; Lemons, Lisbon and Eureka. In a further two years fruiting habits should be sufficiently well known to enable more detailed observations, but at present it appears that citrus can be grown successfully with further research needed on varieties, stocks, cultivation and manurial methods.

Central Australian Gardens.

One must not omit the valuable contribution to the health and morale of rationed personnel in Central Australia by the small gardens conducted at Spinifex, Wyecliffe Wells and Elliott. The tonnage was small, but the produce was appreciated by local hospitals, convoy drivers and passing troops. The climate in Central Australia is vastly different from that of the Northern Territory. The total annual rainfall varies from 12 inches at Alice Springs to about 20 inches at Elliott, most of it falling in December-January. The remainder of the year enjoys sunny cloudless days, generally very warm, although frosts are experienced around Alice Springs in June, July and August. Strong winds are prevalent.

Local production in peace time was scanty, not sufficient even then for the small local population. When the north-south road, the Sturt Highway, of 950 miles, was commenced in 1940 the numbers to be fed increased a hundredfold. Following on the 1941 success in Northern Territory, a small project of $3\frac{1}{4}$ acres at Wyecliffe Wells was commenced by Sgt. O. Ruegg on 1st April, 1942. Many, seeing the bleak red soil on windswept country for hundreds of miles covered only with stunted mulga and spinifex grass, considered the date, " April Fool's Day ", appropriate. The bore, 160 feet deep, gave a 72,000-gallon flow, only sufficient for a small area. It was also highly charged with salts, 80 grains per gallon, half of these being of types injurious to soil.

Production in the remaining nine months of 1942 from these $3\frac{1}{4}$ acres totalled $26\frac{1}{2}$ tons of quality tomato, cabbage, silver beet, lettuce, radish, cucumber, etc. In 1943 the area was increased by four acres at Spinifex, 17 miles south, and by a one-acre garden at Elliott Staging Camp over 300 miles north. Total production reached 67 tons, and in 1944, with a slightly increased area at each place, gave over 103 tons of valuable fresh vegetables. In early 1945 the local feeding strengths declined and the gardens were discontinued.

Bee Culture.

Old Territorians advised that bee farming would not be successful, but satisfactory results are certainly possible if regular sound methods are employed. Full credit for the success of the bee venture must be given to Cpl. R. H. Shimmin, a Victorian bee farmer, who by consistent conscientiousness, energy and use of his previous experience has opened up definite possibilities for local self-sufficiency in honey production. The bees are needed for their aid in pollination, but during 1943, 115 lb. honey and in 1944, 709 lb. were produced, and 2,129 lb. in the first eight months of 1945. The original 16 hives in March, 1943, were flown in by Service aircraft and subsequently Carnolean and Italian queens were both successfully

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INDEX

TO VOLUME 11

Page

A

Agricultural Climatology 115
„ Rehabilitation in Far East by U.N.R.R.A. 63
Agriculture, Research for Post-War .. 111
„ War-Time Expansion 76
Aitken, Y., and Haughton, J. M.— The Species *Pisum sativum* in Relation to Australian Agriculture 35
Anderson, R. H.— The Place of Trees in Land Usage in New South Wales 66
Andrewartha, H. G.— Research to Meet the Demands of Post-War Agriculture in Australia . 111
Apple Production, Varietal Aspects 16
Australia, Rainfall Reliability 188
Austroicetes cruciata, Parasite of 189

B

Bean Seed Weevil Control 139
Birch, L. C.— Diapause in *Scelio chortoicetes* Frogg. (*Scelionidæ*), a Parasite of the Eggs of *Austroicetes cruciata* Sauss. .. 189
Black Beetle, Effect of D.D.T. on 135
Book Reviews— Advances in Grassland Husbandry and Fodder Production (Imperial Bureau of Pastures and Forage Crops) 51
Country Towns of Victoria: A Social Survey, by A. J. and J. J. McIntyre 99
Darwin on Humus and the Earthworm 150
Livestock Improvement, by J. E. Nichols 148
Plants and Plant Science in Latin America, edited by Frans Verdoorn 203
Principles of Animal Production, by C. P. McMeekan and others 202
Propagation by Cuttings and Layers, by R. J. Garner (Imperial Bureau of Horticulture and Plant Crops) .. 52
Root Disease Fungi, by S. D. Garrett 148
The Earth—Our Mother, by B. A. Santamaria 202
The Semen of Animals and Its Use for Articial Insemination, by James Anderson 203
Sheep, by J. F. H. Thomas and others 149
Bowman, F. T.— Some Varietal Aspects of Australian Apple Production 16
Boyle, R. A.— Fertilizer Usage in Australia in Fact and Fancy 82
Bruchus obtectus, Control of 139
Bunt Resistance in Australian Wheats . 28

C

Cheese, Propagation of Cultures 92
Climatology, Agricultural 115
Corrigendum 51
Current Notes and News 50, 97, 146, 200
Currie, G. A.— Education for What? 1

D

Dairy Industry, Modern Trends in 166
„ Research in New South Wales .. 98
Davidson, James (obituary) 151
D.D.T., Effect on Black Beetle 135
„ Present Status as Insecticide .. 135
Dickson, B. T., New President A.I.A.S. 45

Page

Donald, C. M.— The Third Report of the Rural Reconstruction Commission 8

E

Education in Rural Areas 1

F

Farrer, William (Centenary) 72
Fertilizer Restrictions and Sugar Cane 97
Fertilizers, Use in Australia 82
Financial and Economic Reconstruction of Farms 101
Flax, Effect of Temperature and Time of Sowing on Growth 41
Forestry and Land Use in New South Wales 66
Friend, A. H.— Experiments on the Control of the Bean Seed Weevil 139
Fruit, Vegetables and Poultry in Northern Australia 157

H

Haughton, J. M., and Aitken, Y.— The Species *Pisum sativum* in Relation to Australian Agriculture 35
Helson, G. A. H., and Waterhouse, D. F.— The Present Status of D.D.T. as an Insecticide 172
Heteronychus sanctæ—helenæ, Effect of D.D.T. on 135
Host Parasite Relations in Pink Rot of Potato 195
Host Specificity amongst Root-Nodule Bacteria 121
Hutton, E. M.— Present and Future Trends of Tomato Varieties in Australia 128

I

Insecticidal Value of D.D.T. 172
Institute of Agricultural Science, The Australian— Accounts, Statement of 143
Branch Meetings— A.C.T. 95, 200
N.S.W. 95, 144
Queensland 50, 96, 199
S.A. 50, 96, 144, 199
Tasmania 200
Victoria 96, 199
W.A. 97, 145, 199
Council Meetings 45, 93, 142, 198
General Meetings 47, 93, 198
Journal— Change of Editor 97
Report of Business Manager 142
" Report of Editor 94
President 45
Qualifications Committee 97
Ives, W.— U.N.R.R.A.'s Part in Agricultural Rehabilitation in the Far East 63

J

Jones, Lewis Ralph, an appreciation .. 120

K

Kjar, N. A. M.— Notes on Tropical Fruit, Vegetable and Poultry Production in Northern Australia, 1940-45 157

Page

L

Lactic Acid Production from Wheat Starch 185
„ „ „ „ Whey 179
Lactobacillus bulgaricus, Influence of Yeast Extract on 191
Land Tenure in Queensland 50
„ Use and Forestry in New South Wales 66
„ Utilization and Farm Settlement 8
Leeper, G. W.—
Reliability of Rain in Australia as Compared with the Rest of the World 188
The Winter School of Soil Science .. 153
Legumes, Excretion of Nitrogenous Compounds 23
Livestock Improvement, Need for 201

M

McDonald, V. R.—
Some Modern Trends in the Dairying Industry 166
McDonald, W. J. B.—
Some War-Time Expansion in Agriculture—Then What? 76
Macindoe, S. L.—
Centenary of the Birth of William Farrer, 1845-1906 72
Retirement of J. T. Pridham, H.D.A. 74
Magee, C. J.—
Lewis Ralph Jones, 1864-1945 120
Marshall, T. J.—
Tension of Water in a Sandy Soil at Field Capacity 192
Milthorpe, F. L.—
The Compatibility of Protectant Seed Dusts with Root Nodule Bacteria . 89

N

New South Wales, Dairy Research 98
„ „ „ Pest Destroyers Act 202
Nitrogenous Compounds, Excretion of .. 23

O

Obituary Notices—
Clarke, G. W. 100
Davidson, J. 151

P

Peas in Relation to Australian Agriculture 35
Personal Notes 52, 100, 152, 204
Pest Destroyers Act, N.S.W. 202
Potato, Pink Rot of 195
Poultry in Northern Australia 157
Pridham, J. T. (Retirement) 74
Pugsley, A. T.—
Breeding for Bunt Resistance in Australian Wheats 28

Q

Queensland Department of Agriculture Reorganization 146
Queensland, Fertilizer Restrictions and Sugar Cane 97
„ Land Tenure in 50

R

Rainfall Reliability in Australia 188
Ramsay, A. M.—
The Fourth Report of the Rural Reconstruction Commission 101
Reconstruction Commission, Rural—
Third Report 8
Fourth Report 101

Page

Regional Boundaries in Australia 108
Research for Post-War Agriculture 111
Rhizobium leguminosarum, Toxicity of Seed Dusts to 89
„ *trifolii*, Specificity to Hosts 121
Root Nodule Bacteria, Effect of Seed Dusts on 89
„ „ „ Host Specificity in 121
Rothberg, M.—
The Sociology of Soil Conservation in the United States 53

S

Scelio chortoicetes, Diapause in 189
Seed Dusts, Effect on Root Nodule Bacteria 89
Skerman, P. J.—
Intermittent Propagation of Cheese Starter Cultures 92
Societies, Council for Victorian Scientific 200
Sociology of Soil Conservation 53
Soil Conservation in United States 53
„ Science Winter School 153
„ Water Tension in Sandy 192
Streptococcus cremoris, Stored under Paraffin 92
Swaby, R. J.—
Do Legumes Excrete Nitrogenous Compounds? 23
Influence of Yeast Extract on *Lactobacillus bulgaricus* Incubated at Various Temperatures 191
Production of Lactic Acid—
I. From Whey 179
II. From Wheat Starch 185

T

Taylor, J. K.—
Reports on Regional Boundaries in Australia 108
Technical Notes 41, 89, 135, 188
Tilt, J.—
Effect of Temperature and Time of Sowing on the Growth of Flax in the Field 41
Tomato Varieties in Australia 128
Trumble, H. C.—
Agricultural Climatology in Australia 115

U

United States, Sociology of Soil Conservation 53

V

Vegetables in Northern Australia 157
Victoria, Council of Scientific Societies 200
Vincent, J. M.—
Host Specificity amongst Root-Nodule Bacteria Isolated from Several Clover Species 121

W

Wallace, C. R.—
Protection of Plants from Black Beetle by D.D.T. Applied to the Soil 135
Waterhouse, D. F., and Helson, G. A. H.—
The Present Status of D.D.T. as an Insecticide 172
Wheat, Resistance to Bunt 28
„ Starch as Source of Lactic Acid 185
Whey as Source of Lactic Acid 179
White, N. H.—
Host Parasite Relations in Pink Rot of Potato 195
Winter School of Soil Science 153

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introduced. The hives, now some three and four tiers high, have increased to nearly 40, and it is anticipated that yields of 200 lb. of honey per hive per annum may be obtained. Swarming in hot weather needs constant attention, and special shelter precautions are necessary against weather and ant depredations. The destruction of bees in flight by the bird, the Australian Bee-eater, is perhaps the worst difficulty, which has been minimized only by constant use of the shotgun. Native flora has been the main source of food, the most useful being lignum, wattle, eucalypt, kapok, bauhinia trees and small ground flora in season, with bananas, cucurbits, tobacco, and sunflowers among the cultivated crops.

Poultry and Pigs.

The large-scale poultry farm at Katherine proved most successful. The average production per one-year-old bird during 1944 exceeded 165 eggs per annum, which, as it is greater than Australian average, must be considered very satisfactory. Results during 1945 were equally as good, the average daily pick-up for the first eight months being 2,801 eggs from an average of under 6,000 birds, which represents an average of 114 eggs per bird with another sixteen weeks to complete the year.

White Leghorns were preferred, although Australorps in 1945 were little if any inferior. Feeding consisted of prepared dry mash in hoppers, with green feed (lucerne, maize or cereal crop) at midday and wheat grain in the evening with plenty of grit and clear cool water available at all times. The semi-intensive system was preferred, and houses each 18 ft. deep with pens 50 ft. long were erected in a well drained position on the river bank. The original bush timber, mainly tall gums, was left untouched. Special modifications of normal Queensland designs were necessary to maintain adequate ventilation and yet not allow of excess moisture from the heavy storms being blown in on the cement floors.

Day-old sexed chickens were flown in by Service aircraft on daily run from Brisbane during June, July and August, arriving at the farm at Katherine within 50 hours of being hatched. Under normal circumstances losses on each weekly batch of 500 did not exceed 1 per cent., but when weather conditions or mechanical trouble delayed the aircraft for 24 hours, the losses were high and surviving chickens did not subsequently thrive. All stock were tested and proved free from " pullorum ". Production normally increased after termination of the " wet ", with peak in July-August, then gradually declining till December, with the moulting period January-March low. The birds during the " wet " became low in condition. Breeding and local hatching were not attempted because the other method had many advantages for Army purposes, but there appears no reason why it should not be successful.

Pigs have been successfully maintained as unit projects at Adelaide River, Elliott, Barrow Creek, Alice Springs, Banka and other centres. Pure-bred boars and sows of Canadian Berkshire, Tamworth and Large White used for crossing were most successful, but the normal feeding of kitchen refuse needed the addition of minerals and green feed or vitamin substitutes. Some very good quality pork was produced and the future scope for local markets appears limited only by the amount of cheap and suitable by-products available in the area.

Crop Production by Civilians.

In a discussion of this nature, one must not overlook the lead given by the market gardeners before the war. Over a number of years they had shown that successful crops could be grown, provided sufficient attention and encouragement were given. Up to 1940, Mr. Verberg had produced some very good yields of citrus (at Adelaide River) and vegetables at Adelaide River and Coomallie Creek, while Mr. Nixon, at Katherine, was equally successful with vegetables. On the Daley River sweet potatoes had proved successful. Success was not limited to any one method, crop or area. The total produce available from these gardens, however,

was limited and not sufficient for all local needs even in peace time. In addition marketing and transport were not organized sufficiently to make the ventures really satisfactory. During the war years the Army gave encouragement to the few remaining local producers to increase output, and purchased on contract all available vegetables and fruits. While the total amounts were relatively small, they made valuable additions to Army production.

Local growers in the past have also grown successful crops of cotton, but lack of labour and a satisfactory local marketing scheme limited expansion. Very good yields of peanuts have also been obtained at Katherine and Daley Rivers under primitive conditions. Even now one grower without fertilizer and with a variety "Virginia" that had not had any real selection for six years obtains yields around 1,000 lb. per acre. With some seed selection, fertilizer, better cultivation and more efficient threshing methods, the average yield could be increased.

Tobacco was also successfully produced in small commercial quantities before the war. Some air-cured leaf grown at the Experiment Farm, Katherine, in 1944 received favourable trade comments, and during 1945 further work with this crop was being carried out in association with C.S.I.R. Similarly, fodder crops such as lucerne, sorghum, maize, wheat, oats, barley have been successfully grown in small areas, but further research is needed. Pasture work on any scale has not been attempted, but demonstration plots of tropical grasses and legumes in conjunction with the local species gave promise. Here again extensive research and experiments are vitally necessary.

Factors in the Future Agricultural Development of the Northern Territory.

The Northern Territory has been and is today a national bulwark against Asiatic invasion. Tomorrow it can be either an asset or a liability to Australia. It is definitely not a land of "milk and honey" waiting to be tapped by the first agricultural adventurers. No doubt there are some big possibilities for increased settlement, but it is submitted these must be firmly directed along sound lines with special economic and social guarantees until such time as the various industries become firmly established.

The main factors towards success appear to be the following, in order of importance :

(*a*) The size of the defence forces maintained in the area in the future. Any large-sized garrison plus dependents will automatically create a large population with considerable local spending powers.

(*b*) The encouragement given to the cattle industry by means of land policy, improvement of cattle quality, special concessions, abattoirs, cold storage and port facilities, together with a marketing scheme. Development of irrigated pastures could follow from any large-scale irrigation projects.

(*c*) The tourist industry if developed on progressive lines will attract large numbers of travellers who will provide large local spending powers, not only in themselves but also in the people who are engaged in arranging for their comfort and travel.

(*d*) The mining industry appears to be capable of expansion and may even become of major importance.

(*e*) The local populations developed by reason of these four main activities will demand fresh commodities such as fruit, vegetables, poultry products, milk, fish, meat, etc., all of which should be grown or obtained locally. A reasonable basis per 100 head of population is one acre of vegetables and half an acre of fruit. Lack of a guaranteed market is the main retarding factor, and some such scheme of guaranteed minimum prices as was applied

in northern Queensland during war years appears essential. Grain sorghums for local consumption by poultry and other stock could easily be grown in order to reduce special food importations.

(*f*) Peanuts, tobacco, cotton and tomatoes can be grown successfully, and these, together with other products still in the experimental stage, might provide the basis for an export trade to the south capable of rapid development. Such a development however depends mainly on economic factors and reliable markets.

(*g*) Development of secondary industries for local markets and perhaps export appear possible, but again is dependent on complex economic and other considerations.

Conclusion.

As stressed earlier, this article is simply an indication of what has been achieved in this area by Army personnel, only a very small proportion of whom before the war had any knowledge of the specialized subjects of tropical fruit, vegetables and poultry farming. With the recent cessation of hostilities and the large reductions in feeding strength, anticipated plans have been made to close down the majority of Army farm projects, when harvesting of the present crops is completed in late 1945. Close liaison has been maintained with the civilian departments that will administer the area in the post-war period with the object of Army assets in the form of land, buildings, farm plant, etc., being utilized to serve Darwin under a civilian régime.

Although large-scale irrigation is possible in many areas, thus increasing pastoral possibilities, the main point to be stressed is that the immediate future of agriculture in Northern Territory is dependent on the post-war provisioning of the Darwin and local garrisons, and on the policy of the Government regarding the economic development of the Territory. Unless some scheme of guaranteed prices with an outlet for all produce grown is implemented, any large-scale agricultural ventures would be extremely risky.

Only the fringe of agricultural and pastoral knowledge of this huge belt of country has been touched. Extensive research on all angles such as water, soils, transport, roads, plants, diseases, pests, animal husbandry, climate, etc., together with the economic and national aspects is essential before any large-scale development could be recommended. C.S.I.R. is already interested in these scientific investigations, and it is hoped that comprehensive work of this nature will be given a high priority.

Acknowledgement.

Special acknowledgement is made to :

(*a*) Department of the Army for permission to record the above information.

(*b*) C.S.I.R. officers (particularly Drs. Prescott and T. J. Marshall and Messrs. E. M. Hutton and G. A. Helson) for advice and information, much of which has been included in this article.

(*c*) Members of Northern Territory farm companies, A.A.S.C., actively concerned with this work, particularly Major L. A. Campbell, Capt. H. K. C. Mair and Lieut. J. Scott-Young.

The author also wishes to stress that the conclusions reached are his own and may not necessarily be those of the Department of the Army, which however desires that the experiences gained and agricultural data obtained be made available to civilian scientific workers for use in the post-war era.

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Some Modern Trends in the Dairying Industry*

By

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The history of milk production in Australia is crowded with instances of prodigal waste of valuable food in the form of skim milk, buttermilk and whey. The gross inefficiency resulting from this waste has played a large part in keeping the dairying industry on a low economic plane as compared with the economic status of other great primary industries. The proper utilization of all the solids of milk, for which many people are planning at present, should enable the industry to attain a measure of economic status and stability that it has never known before.

Efficiency of Production.

The two major items concerned with the efficient production of milk are actual cost of production per gallon of milk and the quality of the milk or cream at the time of arrival at the treatment centre. There is no doubt that the trend of quality has been downward in recent years, but this has been due to shortages of labour and materials during the war period, and one can confidently expect a general improvement in quality as conditions revert to normal. The same thing applies, to a certain extent, to economic efficiency of production. For more than 20 years, farmers have been urged to increase their efficiency by conserving fodder and using " balanced " rations, by using high quality pure bred bulls to produce their own replacement stock, and by using the results of year to year herd testing as a basis on which to cull unprofitable cows from their herds. It has often seemed that all such pleas have been in vain, but today one can discern a growing interest in these things among dairy farmers generally. This interest has not led to action in many cases, but there are strong indications that it will do so before long. The prime cause of this is hard to pinpoint, but it is certainly associated with wartime publicity regarding the national importance of milk production, the steady work of the Agricultural Bureau system, and the increasing economic stability the industry has enjoyed since 1935.

It is commonly stated that the present high price of milk is leading to more and more inefficiency, since it enables dairy farmers to use poor methods and yet show profitable returns. Careful examination reveals that this is a short-sighted and unprogressive view of the present position. Up to the middle thirties, dairy farming as an occupation had two major features—long hours and low pay. Even as late as 1938, the price of milk was 6*d*. to 7*d*. per gallon in South Australia, which was less than the cost of production on most farms (in Western Australia a survey in 1939 showed that cost of feed alone was more than 6*d*. per gallon on some farms[1]). The obvious result of these low prices was that farmers were forced to work excessively long hours, which left them insufficient time or mental energy to give serious consideration to the efficiency of their methods. In the last few years, the price of milk has been increased by about 100 per cent. in South Australia, but shortages of labour and materials have made it necessary for the average farmer to work just as long hours in an equally poor milking shed, and to request as much help from his family as he did in days gone by. That is the real reason why so many farmers are showing good financial returns at the present time. If we consider that the homes, the working men's quarters and the farm buildings of today are good enough, if we

* An address given to the South Australian Branch of the Institute.

consider that farmers should work continuously with no time to plan and think, and that the wives and families of dairy farmers should continue to fill in their " spare " moments with unpaid drudgery as in the past then the present price of milk is far too high. If, on the other hand, we grant that children in our dairying districts should be given reasonable opportunities for education and recreation and that the farmer must be given a chance to organize the working of his business and to introduce new and better methods of production, then the price of milk will have to remain at somewhere near its present level in relation to the price of other goods. The present position is merely a passing phase. If and when dairy farmers have some money to spare, that money will gradually be used for all-round improvement of the farm, and for improving the wages and conditions of farm employees. The dairying industry needs an influx of keen, educated young men as farm owners and employees, but such men will not be attracted unless the price of milk is maintained at a level that will ensure reasonably good conditions.

Another trend, which is more noticeable perhaps in New South Wales than in other States, is the use of large machines and contract gangs for certain types of seasonal work. This applies particularly to conservation of hay and silage. This work can be done much more cheaply by big mechanical units than by individual farmers with small machines. The day may not be far distant when all subdivision on dairy farms will be done with electric fences. These fences could be removed at harvest time to enable large machines in a very short time to cut all the silage or hay that it was desired to conserve. One New South Wales dairy company is considering the possibility of working on a share basis with all the farmers who supply them with milk. The factory will guarantee to deliver to the farmer all the feed he requires throughout the year. The farmer can then concentrate on the proper care and milking of the cows and careful holding of the milk or cream on the farm. Such a system would enable each man to keep more cows and would enable him to confine his physical effort to a reasonable daily routine. The widespread application of this idea would undoubtedly increase the efficiency of milk production, because it would tend to develop two groups of specialist farmers—one to grow the feed, the other to utilize it for milk production.

Efficiency of Processing and Distribution of Milk.

Many of those engaged in the processing of milk and milk products are showing an increasing resolve to eliminate the present inexcusable waste of protein and milk sugar in the form of skim milk, butter milk and whey. The moves that are being made at present along these lines constitute the most important trend in the history of dairying in Australia. Ever since the farm separator was introduced early in this century butter has dominated the dairying industry of the Commonwealth and in recent years more than 70 per cent. (and at times up to 83 per cent.) of the milk produced in Australia has been used for the production of butter. Australia and New Zealand have led the world in devising the best methods, and producing the best machines for the manufacture of high quality butter. While we may be justly proud of the efficiency with which we have learnt to turn cream into butter, the fact remains that butter manufacture is the most wasteful and least efficient way of utilizing milk for human consumption. If a cow is given 100 lb. of digestible dry matter she will convert that food into milk containing 18 lb. of dry matter for human consumption. If the milk is used for cheese making, the figure drops to 9·4 lb., and if it is put through the separator, and the cream made into butter, then only 5·6 lb. of the original 18 lb. of food is made available for human consumption. These figures provide the logical reason for the lowly economic status of dairy-farming among the great primary industries. Out of every 18 lb. of food suitable for direct human consumption that has been produced by cows in Australia, we have been content to consume directly only 5·6 lb.—the rest has either been wasted or fed to farm animals. Geddes[2] estimates that Australia's output of skim-milk and butter-

milk in 1938-39 contained about 150,000 tons of protein, that less than 8,000 of this was consumed (as pig meats, etc.) by humans, and the other 142,000 tons, or 95 per cent., was completely wasted. He makes the astounding but logical assertion that the dairying industry allowed as much protein to go to waste in 1938-39 as was contained in the 320,000 tons of mutton and lamb and the 560,000 tons of beef which Australia produced in that year. Incidentally the protein of milk pound for pound is much more valuable in the human diet than the protein of meat as the latter lacks a number of amino acids that are known to be essential to health and growth whereas all the amino acids are present in milk protein. One may surely be permitted to describe this waste of valuable food as colossal, but the whole story is not yet told. We must add to the 140,000 tons of protein the loss of milk solids in the form of whey from cheese factories. Assuming that 30 per cent. of all cheese whey is fed correctly to pigs (a liberal assumption) and that all the milk sugar in that whey is returned in the form of pork for human consumption, we still have a complete waste of 2,000 tons of protein (lactalbumin) and more than 10,000 tons of milk sugar, not to mention a further 2,000 tons of minerals in a delicate natural balance ideally suited to the human diet. The basic strength of the dairying industry is well shown by its ability to stand up to such an enormous burden and yet climb to second place among Australia's primary industries, but waste on such a scale surely calls for drastic measures in the interests of national economy. It is not only the concern of those directly engaged in dairying, because the existence of such waste in an industry with a gross value of £53 million sterling must have an effect financially on every person in the community.

There is, of course, a reason why this position has been allowed to develop. Until recent years, transport difficulties made it virtually impossible to transport whole milk to factories in most of our dairying districts. This position still persists in areas like the lower and middle north and parts of the south-east of South Australia, and the milk produced in those areas will probably be used for butter manufacture for many years to come. This supplies a sufficient reason for the widespread popularity of butter making in the early stages of the development of dairying, but the explanation of the domination of the industry by butter right up to the present day is not so simple. The Dairy Farmers' Co-op. Co. of Sydney draws some of its 80,000 gallons of milk per day from areas up to 250 miles away, yet many closely settled intensive dairying areas in northern New South Wales and Queensland are still devoted almost entirely to butter manufacture, although collection of whole milk in those areas in large amounts would be relatively easy. One imagines that consideration of the money invested in butter making machinery has made factory executives loth to change over to the handling of whole milk. Such a change would also necessitate the careful training of men in new processing methods, and would require the application of a high degree of organizing and executive ability. Most big companies, both co-operative and proprietary, have persisted with butter manufacture because of these problems, but a notable exception to the rule is the Hunter Valley Co-op. Co. at Hexham, N.S.W. This company in the last ten years has changed from a butter and cheese factory into a modern whole milk treatment plant, handling over 50,000 gallons of milk per day and capable of producing city milk, whole or skim milk powder, cheese, butter, powdered butter milk and (if required) dried whey. Milks of varying quality can be treated in the different departments, and the company can alter its output of various milk products according to the demand and price levels of those products at any given time. This is the milk treatment plant of the future, and this is the way in which the problem of waste and inefficiency in the dairying industry can be solved.

The problem is clear-cut, and the solution has been found to work in practice by the Hunter Valley Co-op. Co. and by the Nestlé and Anglo-Swiss Co., but can this solution be applied to the Australian dairying industry generally ? Fifty thousand gallons at Hexham and 100,000 gallons at Dennington is still only 5 per cent. of the

country's daily production of three million gallons. Can we find payable markets for the milk by-products of the other 95 per cent. ? Perhaps the answers to these questions will come more readily if we take a definite example of a possible future change over to whole milk treatment. In 1955 or 1965, for example, our milk production may be handled as shown in Table I.

TABLE I.

Liquid market milk	30%	(1942-3, 18%)
Butter making	40%	(1942-3, 71%)
Condensed milk and whole milk powder	18%	(1942-3, 5%)
Cheese making	10%	(1942-3, 6%)
Ice cream, baby foods	2%	
	100%	

On our present production of 1,100 million gallons this would entail the production of these commodities in the quantities shown in Table II.

TABLE II.

Market milk	330 million gallons	(1942-3, 190 million gallons)
Butter	100,000 tons	(1942-3, 170,000 tons)
Cheese	50,000 tons	(1942-3, 35,000 tons)
Milk powder	100,000 tons	*(1942-3, approx. 50,000 tons together)
Condensed and evaporated milk	35,000 tons	
Ice cream	30,000 tons	(1942-3, figures unobtainable)

* Estimate only.

Since the present trend in dairying is toward expanded production, it is obvious that the disposal of the above quantities of liquid milk, cheese, milk powder, condensed milk and ice cream will not solve the marketing problems of the future. Projected schemes for irrigation, and for the rehabilitation of ex-service personnel may result in a marked increase in Australia's milk production over the next ten years or so.

By that time, however, the population of Australia may have increased considerably, and the standard of nutrition among some of the nations of Asia and the Pacific may have been raised sufficiently to create a strong demand for protective foods like milk solids. Future marketing problems, therefore, will depend to such a large extent on national and international politics that any forecast concerning them would be, at best, merely conjecture.

On the other hand it is feasible, and may be, useful to examine the possibilities regarding the disposal, in the near future, of the amounts of milk powder, condensed milk, cheese, etc., mentioned in Table 2 as desirable proportions in which to use the total milk supply.

If it can be shown that the listed amounts of those products can be disposed of as things are at present, then it seems reasonable to assume that markets will expand to absorb any normal increase in future production. For the foregoing purpose, certain details will be presented in respect of each milk product in the table :

Market Milk. Our present consumption is about 190 million gallons. The rise to 330 million gallons would provide just one pint per head per day—considerably less than nutrition experts consider necessary for ideal nutrition. The local market *will* absorb the 330 million gallons if the purchasing power of the people can stand the strain, and nutrition experts state that the consumption of about one pint of milk is essential in the interests of national health.

Butter. Normally, about 105,000 tons of butter are consumed locally, and there is little possibility of this demand decreasing unless the price rises much above 1s. 9*d*. per lb. If, however, it is found that other products can be made from milk and sold at a greater profit, then factories will refuse to make butter at this price.

England will continue to ask for butter in the future, because the dairying industry there learned long ago that butter production was a wasteful and uneconomic means of utilizing milk. When Australia in her turn learns that simple truth and starts to act upon it we may find there will be little if any butter available for export. America is by far the greatest dairying country in the world but she exports no butter for she too has found that butter must play a subsidiary not a dominant part in a well-balanced dairying industry. If margarine ever becomes prominent in Australia, its success will probably be due to the refusal of dairymen to allow the use of their milk for butter manufacture at the price the Australian consumer is willing to pay.

Whole Milk Powder. At various times it has been suggested that large-scale production of whole milk powder should be undertaken in Australia, but early enthusiasms have often been dampened by reports of big problems and big failures. It is even stated that a large quantity of whole milk powder was fed to pigs some years ago because no market could be found for it. The infancy of every industry has been attended by failures, but today it would appear that the technique of producing whole milk powder has reached a stage at which a high quality product can be manufactured consistently. The one big problem that remains is the tendency of whole milk powder to develop an oxidized flavour after the tin has been opened for some time. Even this defect may soon be brought under control by compressing the powder into cubes of various sizes to force out the air and thus prevent oxidation and tallowyness from developing. If we can produce whole milk powder of consistently high quality, and with the ability to withstand long periods of storage, it should not be difficult to find markets.

In both England and America, bakers are required to add 5 per cent. whole milk powder to all the flour used for the production of bread. If similar legislation were enacted in Australia, the bread industry would absorb over 30,000 tons of whole milk powder per year. One would not expect much opposition from bakers to this proposal as the use of milk powder improves the texture and keeping quality of the bread in addition to improving its nutritive value. It has been shown.[3] that such bread is superior as a food to whole meal bread. India may soon be seeking about 200,000 tons of milk solids per year, and among the peoples of Asia and the Pacific Islands 50-70,000 tons of whole milk powder would represent a very small percentage of their requirements. If pre-war conditions return in these areas, the possibility of new markets will be small, but " pre-war conditions " have seldom returned to any country after a big war, and present indications seem to point to the possibility of greatly expanded markets for protective foodstuffs in the Pacific and Asia.

Cheese. The 50,000 tons of cheese in our list should present few problems as far as disposal is concerned. Very little has been done, in the last few centuries, to improve our methods of turning milk into cheese. Greater changes in this regard may be made in the next two decades than have been made in the last two thousand years. If we can produce small, attractive packages of cheese free from mould growth, and possessing a uniform desirable flavour Australians may easily reach an average consumption of 10 lb. or more per head per year, and thus make a market for 40,000 tons of cheese.

Whether this desirable goal is reached or not, the amount of cheese we are likely to produce would not be a significant addition to the world export, and if it is of good quality, it is reasonable to assume that a market will be found for it. Canada exported some 250,000 tons of cheese in 1944.

Ice Cream. The amount of milk credited in Table II for manufacture of ice cream and baby foods does not exceed the amount that could normally be absorbed by the extension of markets already established. The 30,000 tons of ice cream mentioned would supply Australians with 9 lb. per head per year, compared with a normal consumption of 16 lb. per head per year for the 120 million people of the U.S.A. This would indicate that the increased consumption that has been assumed

is not excessive. No official figures of present consumption of ice cream in Australia are available.

Other Milk Products. From the foregoing it would seem possible to make drastic alterations to the present balance of production of various milk products in Australia without any great fears of financial disaster. Even these changes, however, would still leave us with a considerable waste of milk solids—protein and sugar—unless more efficient use was made of butter milk and whey. Actually, disregarding skim milk, we would still be faced with about 10,000 tons of dry matter in the form of butter milk and 25,000 tons in the form of whey. Undoubtedly a considerable portion of these two products will be used for feeding to pigs, calves and poultry, but much of it can, and will, be processed for direct human consumption. The new method of making butter without a churn enables the butter milk so obtained to be made up into a powder that is highly palatable and which could be used with breakfast foods, for ice cream manufacture, and home cooking, particularly in desserts of various types.

The drying of whey offers peculiar difficulties, but these will be overcome and the valuable milk sugar and protein that whey contains will not be poured out on back paddocks on roadsides or into drains or the open sea as is at present being done. Dried whey is an excellent medium for the production of penicillin. England bought 30,000 tons of it for this purpose from Canada in the past year, and perhaps it will be used similarly in Australia. Another untapped market for this product is in the confectionery business, but uses that are more immediately probable are the production of lactic acid and pure lactose or " sugar of milk ".

The Future of the Dairy Industry.

Finally, one might mention that these many and varied aspects of the dairying industry of the future are not nebulous possibilities which we may or may not see at some dim and distant time. All of them are being attempted in one or other of the dairying countries, and many of them are actually being done in Australia at the present time. The simple truth is that Australia is a long way behind many other countries with regard to economic efficiency in dairying. If even a portion of the waste to which we have turned a blind eye in the past can be eliminated, if we resolve to utilize as much as possible of the whole milk which the cow produces with such commendable efficiency, then dairying will soon become the greatest of our primary industries, and no Australian need fear the consequences of such an event.

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The Present Status of D.D.T. as an Insecticide

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The new insecticide D.D.T. has aroused very great interest since its possibilities were first publicized early in 1944, largely in connexion with its effect on insect vectors of human disease. More recently, attention has been drawn to the possibility of its wide usefulness against agricultural, horticultural and domestic insect pests. In this article, some attempt will be made to indicate briefly its present status as an insecticide.

The initials D.D.T. stand for the chemical compound p, p-dichlor-diphenyl-trichlorethane. This material was first synthesized in 1874, but its value as an insecticide was not recognized until Müller, a Swiss research worker, discovered that it had insecticidal properties. His work was confirmed by Wiesmann.

The great value of D.D.T. as an insecticide is due to its unusual combination of the following properties : its effectiveness in extremely low concentrations, its action both as a contact poison and as a stomach poison, and its stability or resistance to breakdown, which results in it retaining insecticidal action for prolonged periods.

In 1942, the Geigy Company of Switzerland took out two British patents, and in 1943 an American patent, covering the use of D.D.T.-containing insecticides. Large-scale manufacture is now in progress both in England and America, and Australia is also producing substantial amounts.

Forms in which D.D.T. may be Used.

D.D.T. may be applied either as a dust or as a spray ; it has no fumigant action.

Dusts.

Dusts containing from 0·5 to 10 per cent. D.D.T. on an inert carrier have been used extensively both in experiments and in the actual control of insects. Commercial D.D.T. cakes readily on grinding or mixing unless 75 per cent. or more of an inert carrier (such as pyrophyllite, talc, or kaolin) is present. It is probable that most manufacturers will provide for the sale of dusts containing 10 per cent. D.D.T. or less, prepared either by thorough mechanical mixing or by spraying a solution of D.D.T. on to the agitated powder, this latter process resulting in most, if not all, of the particles being coated with the insecticide.

Dusts have been used extensively to control the human body louse, which is the vector of typhus, since, in dust form, D.D.T. is readily applied without harm to infested individuals by blowing the powder between the clothing and the body of the wearer. Dusts have also been used in some situations for the control of mosquito larvæ, because of the availability of dusting machinery hitherto used to distribute the less effective paris green over the breeding grounds. For this purpose, however, D.D.T. dusts have now been largely replaced by oil solutions.

In the initial stages of testing D.D.T. as an agricultural insecticide in Australia during 1944-45, dusts were largely used because, at the time, this was the most convenient method of application. These dusts consisted of 90 per cent. pyrophyllite (a naturally occurring mixture of pinite and siliceous pyrophyllite) and 10 per cent. D.D.T. Kaolin or talc may also be used as the inert carrier. These carriers should be neutral, since alkaline dusts may react chemically with D.D.T., and at least 90 per cent. should pass through a 200 mesh British standard sieve.

Sprays.

D.D.T. may be applied as a spray in the form of a suspension in water (in which its solubility is extremely low), as a solution in organic solvents, or as an emulsion.

(*a*) *Suspension in Water.* D.D.T., in contrast to the dust mixture of 90 parts pyrophyllite and 10 parts D.D.T. already mentioned, is not readily wetted by water. This mixture, primarily designed for application as a dust, has also been used to produce a spray by agitation with water. A mixture of D.D.T. and soap powder is also readily wetted by water, but, to prevent excessive loss by run-off, not more than 1 per cent. of soap should be used.

D.D.T. may also be dissolved in a water-miscible solvent, such as methyl or ethyl alcohol, acetone, or pyridine. When these solutions are diluted with water, D.D.T. is thrown out into fine suspension. Acetone, which dissolves about 50 per cent. D.D.T., is not a suitable solvent, however, because the particles of D.D.T. thrown out on dilution tend to aggregate. The suspension resulting from the dilution of a solution of D.D.T. in ethyl alcohol is excellent, but the solubility of D.D.T. in this solvent is low (about 1·5 per cent.), consequently excessive amounts of alcohol must be used to obtain an aqueous mixture containing an adequate concentration of D.D.T.

(*b*) *Solutions in Organic Solvents.* D.D.T. is soluble in many organic solvents, some of which are useful for household sprays and for other purposes where toxicity of the carrier to the insect substrate is not a factor. Aromatic compounds are often better solvents than aliphatic compounds, and there are some materials and mixtures of materials which will dissolve at least an equal weight of D.D.T. For household sprays kerosene is used as the solvent, while for spraying swamps for the control of mosquito larvæ the less volatile diesolene is used. Kerosene is also a convenient solvent for D.D.T. when surfaces are treated to obtain a deposit of D.D.T. for residual effect.

(*c*) *Emulsions.* A number of emulsions have been used abroad for the control of insects of medical importance (e.g., for impregnation of clothing against body louse), and also against agricultural pests. Since some of the solvents and emulsifiers used in these formulations were not readily available in Australia, it was necessary to test materials which were available. Earlier work by C.S.I.R. had shown that a solvent naphtha emulsion at concentrations below 1 per cent. solvent naphtha was non-injurious to potato plants. It was found that solvent naphtha would dissolve about 20 per cent. D.D.T. at ordinary temperatures, and that a satisfactory emulsion could be made with this solution. Tests showed this emulsion to be highly toxic to many insects, such as the larvæ of the potato moth (*Gnorimoschema operculella*). A stock solution for the preparation of this emulsion is made by dissolving 1 lb. of D.D.T. in five pints of solvent naphtha (boiling range 90-190° C.) and adding to this half a pint of an emulsifier (the sodium salt of an alkyl naphthalene sulphonic acid mixed with pine oil). This quantity of stock solution, when diluted with water to 100 gallons, produces a spray containing 0·1 per cent. D.D.T.

Attempts to incorporate D.D.T. in some white oil emulsions have not been satisfactory, since the conventional petroleum oils seldom dissolve more than 5 per cent. D.D.T. In order to increase the concentration of D.D.T. in these oils, it is necessary to add a material such as xylene, in which D.D.T. is very soluble. When these stock white oil concentrates containing D.D.T. are diluted to the final spray strength, it is often found that D.D.T. is thrown out of solution and adheres to the sides of the containing vessel. Another disadvantage of D.D.T.-white oil emulsions is suggested by the inhibition of growth observed in potted French bean seedlings treated in the glass-house, and by reports of foliage injury in apples.

Emulsions have also been prepared using eucalyptus oils as solvents for D.D.T. These oils dissolve about 25 per cent. D.D.T. at ordinary temperatures and very

stable emulsions may be produced. These emulsions show promise in the experiments already carried out, but further work is necessary.

Most emulsions so far prepared suffer from one or more defects. For instance, solvent naphtha obtained by distillation from coal tar is very variable in composition, and is thus not a suitable solvent for the preparation of a uniform emulsion. Investigations are proceeding to evolve more satisfactory formulations for preparing uniform D.D.T. emulsions, and it is probable that solvent naphtha will be replaced by other materials, the composition of which is less variable.

Methods of Application.

Many of the methods of application of D.D.T. are the same as those used for other insecticides, namely the conventional spray and dust gun. Although the apparatus used is extremely varied and cannot be reviewed here, brief mention should be made of the use of the aeroplane. The extremely low dosages of D.D.T. required for the control of many insects make it possible for an aircraft to carry a paying load of insecticide containing D.D.T., although this would not be possible with many other insecticides. Allied aircraft have been used extensively in various theatres of war to spray inaccessible swamps or large areas of country with D.D.T. in oil for the control of mosquito larvæ. Aeroplane application has been so satisfactory for this purpose that it is certain that this means will be adopted also for other insects where large areas of country are involved.

Solutions in organic solvents are not generally suitable for application to agricultural crops with the standard appliances now in use, because the solvent is often toxic to plants. However, it is probable that some will find extensive use if the aerosol method of application can be satisfactorily adapted for this purpose. An aerosol is a suspension of fine solid or liquid particles in air, which means that both dusts and sprays may be regarded as aerosols if the particle size is small enough. One convenient method of producing liquid aerosols is to mix the insecticide materials with a gas, such as freon (dichlorodifluoromethane) or methyl chloride, which liquefies fairly readily under pressure at ordinary temperatures. This mixture is stored in a cylinder fitted with a capillary tube. When the capillary tube is opened, the pressure of the gas inside the cylinder forces the liquid out. At the orifice of the tube the liquefied gas volatilizes and, in doing so, disperses the insecticide in a very finely divided form. Cylinders containing from 1 to 15 lb. of a mixture consisting of liquefied gas, lubricating oil and pyrethrins, with or without D.D.T. and sesame oil (a pyrethrin activator) have been used very extensively, and with great success, by the armed forces, principally for the control of mosquitoes and flies. Thus, a discharge of four seconds' duration from a 1 lb. aerosol bomb, as these cylinders have been called, will kill most, if not all, mosquitoes in a 1,000 cubic foot tent or room. This 1 lb. bomb is very compact, occupying much less space and being considerably lighter than the equivalent amount of the more conventional type of insecticide spray based on kerosene. Its peace-time applications will be many, for the aerosol is effective both under confined conditions and in the open. Thus a 1 lb. bomb contains sufficient insecticide to kill adult mosquitoes in an acre of country, the insecticide being released as the operator walks up and down through the area which it is desired to disinfest.

The aerosol formulæ originally developed for the armed forces are now in process of modification for use on agricultural crops, and suitable machinery for their application is being developed. Some of these developments have been described in the literature. A suitable machine for some crops consists of a container for the aerosol mounted on a light frame carried on bicycle wheels. The container is connected to a number of special delivery nozzles which are mounted on two booms, one behind the other, adjustable for height and width of row. The aerosol is discharged into a canvas hood covering the framework of the machine. This hood temporarily

confines the aerosol in the vicinity of the plants and enables the machine to be used under gentle wind conditions. In one series of experiments, approximately 10 lb. of aerosol were used per acre, and this was delivered from a machine travelling at a speed of three to five miles per hour. This method of application, with its advantages of lightness of machinery, cheapness of construction and ease of manipulation, particularly for market garden crops, has a very great future.

The Toxicity of D.D.T. to Insects.

Agricultural Insects.

An extensive programme of research on the use of D.D.T. against agricultural and horticultural pests is in progress in many parts of the world, including Australia. D.D.T. has been reported to be very effective against a wide range of insects, but there are some notable exceptions ; for example, the cotton boll weevil (*Anthonomus grandis*), the cotton aphid (*Aphis gossypii*), the cotton leaf worm (*Alabama argillacea*), the Mexican bean beetle (*Epilachna varivestis*) and the Mexican butterfly (*Anostrepha ludens*). This list will doubtless increase as further work is carried out. It is also interesting to note that mites are not affected, whereas their insect predators may be. Thus, in some fruit-growing areas serious outbreaks of red spider have followed the experimental use of D.D.T. for the control of codling moth, because the predaceous Coccinellid beetles which normally keep the numbers of mites down at a very low level were killed by the D.D.T. treatment.

The results of preliminary experiments carried out by the Council for Scientific and Industrial Research have shown that D.D.T. is very effective against a large number of agricultural and horticultural pests. This includes certain species which could not be adequately controlled by insecticides used previously. On the other hand, a few pests proved to be resistant to D.D.T. in the preparations and concentrations used.

Experience gained in trials with dusts and sprays containing D.D.T. is summarized below. In most cases the dusts were applied at strengths of 2 per cent D.D.T. or lower and pyrophyllite was used as a diluent. The spray used was generally the D.D.T.-solvent naphtha emulsion diluted to contain from 0·05 to 0·2 per cent. D.D.T. This spray was not injurious to the plants.

TABLE I.

Insects against which D.D.T. was Effective as a Dust or a Spray.

D.D.T. Dust.	D.D.T. Spray.
Green vegetable bug (*Nezara viridula*).	Green vegetable bug (*Nezara viridula*).
Potato moth (*Gnorimoschema operculella*).	Potato moth (*Gnorimoschema operculella*).
Cabbage moth (*Plutella maculipennis*).	Cabbage moth (*Plutella maculipennis*).
Cabbage butterfly (*Pieris rapæ*).	Cabbage butterfly (*Pieris rapæ*).
Cabbage centre grub (*Hellula undalis*).	Oriental peach moth (*Cydia molesta*).
Cabbage cluster grub (*Crocidolomia binotalis*).	Codling moth (*Cydia pomonella*).
Common cluster grub (*Prodenia litura*).	Pear slug (*Caliroa limacina*).
Corn earworm (*Heliothis armigera*).	Green jassid (*Empoasca fabæ*).
Green peach aphis (*Myzus persicæ*).	Bean aphis (*Doralis fabæ*).
Potato aphis (*Macrosiphum gei*).	Black peach aphis (*Anuraphis persicæ-niger*).

The D.D.T. dust and the D.D.T. spray used were ineffective against the cabbage aphis (*Brevicoryne brassicæ*) while the spray was ineffective against the woolly aphis (*Eriosoma lanigerum*) and red spider (*Tetranychus urticæ*).

A great deal of work still remains to be done to discover all the pest which can be controlled, those which are not affected, and the best means of application to crops. Another important aspect which must be explored fully is the effect of D.D.T. upon insect parasites and predators which may be destroyed by its use. It is possible that the indirect effects so produced upon the population densities of their hosts may make necessary some modification of the manner of application used, or even warrant the discontinuance of the use of D.D.T. against certain pests. Bees

are also affected, but, on the evidence available at present, if insecticides containing D.D.T. are applied to plants in flower, there is no reason to expect that the danger to bees visiting the flowers would be greater than if materials containing arsenicals were used. As far as possible, however, treatment of plants in flower should be avoided.

Insects of Medical, Veterinary and Household Importance.

A great deal of work has been done during the war years on this group of insects, particularly against the principal insect vectors of disease, namely mosquitoes (malaria, dengue fever, etc.), lice (typhus) and flies (dysentery, etc.).

(*a*) *Dusts.* Dusts containing D.D.T. have been found to be very effective against surface-feeding (Anopheline) mosquito larvæ, lice and cockroaches. Thus, D.D.T., which is from 10 to 100 times as toxic to Anopheline larvæ as Paris green, exercises effective control when used at the extremely light dosage of 0·1 lb. or less of D.D.T. per acre. A 2 per cent. D.D.T. dust was used in some of this work. However, the difficulty of producing D.D.T. dusts sufficiently fine to be swallowed by the larvæ, and the usually greater ease of application of oily solutions of D.D.T., have resulted in oils being the preferred vehicle in most cases.

As mentioned earlier, dusts containing 5 or 10 per cent. D.D.T. are in use for the control of lice, either for disinfestation, or as a protective measure. Following the outbreak of typhus in Naples in January, 1944, over 1,300,000 civilians were dusted, and within three weeks the outbreak was completely under control. This is the first occasion in medical history that a typhus outbreak has been arrested in mid-winter. Promising results have also been obtained in experiments with lice infesting other animals. D.D.T. dusts are very effective against fleas, both on humans and on animals, and protection is afforded against reinfestation so long as the dust remains on the body.

Cockroaches, which are comparatively resistant to many poisons, can be controlled by dusts containing 10 per cent. D.D.T., lower concentrations giving less satisfactory results, especially against the German cockroach (*Blatella germanica*), which is probably one of the most difficult species to control.

(*b*) *Sprays.* Sprays containing D.D.T. have been used both to produce direct effects on the insects hit by the droplets, and also to obtain residual films of D.D.T. on surfaces where the insects to be controlled will come in contact with the poison.

Sprays containing 0·5 per cent. D.D.T. in kerosene are extremely effective against adult flies and mosquitoes, although the onset of toxic symptoms following application of the spray is slow. This disadvantage may be remedied by the incorporation in the spray of a rapid knockdown agent, for instance, pyrethrins or certain organic thiocyanates. Such sprays are effective also against many other insects, although there are some exceptions, for instance, the German cockroach mentioned above.

Perhaps even more important in many cases than the initial contact effect of a D.D.T. spray is the fact that surfaces receiving a sufficient deposit of spray retain their toxicity for considerable periods. The D.D.T. can be applied by spray-gun or brush, either as a kerosene emulsion or incorporated in paint. The amount required in paint has been found to vary from 0·5 per cent. in oil-bound water paints to 5·0 per cent. in oil paints. A house fly resting on a surface treated with D.D.T. at the rate of 50 mg. per sq. ft. absorbs sufficient poison in a few seconds to kill it, although the first symptoms may not appear for 15 minutes or more, and death may not occur for several hours.

The application of D.D.T. to kitchen walls, wire screens and other places favoured by flies is a very effective means of reducing fly nuisance. Because of its low volatility and resistance to breakdown, D.D.T. will remain effective for many months. Even

when rooms are treated with D.D.T., it is still desirable to use wire screens because, if flies are abundant and are continually entering, there will always be some flying about which have not been present long enough to become affected. All flies in treated premises should, however, die overnight.

Contact with treated surfaces will kill many other insects, although the period of contact and the concentration required vary somewhat. These insects include adult mosquitoes, bed bugs, lice and fleas (treated clothing) and silverfish. Treated surfaces are slightly repellent to some insects (e.g., some mosquitoes, flies, cockroaches) in the sense that the insects do not rest on them as long as on untreated surfaces, although the effect is only noticed following contact of the insect with the surface. The absence of any distance repellent effect is to be expected from the very low volatility of D.D.T. Eradication of bed bugs can be achieved by treating surfaces over which the bugs must pass on the way to or from their hiding places.

Because D.D.T. in solution in oil may be toxic to the animal it is best applied as an emulsion. D.D.T. emulsions have given very promising results in the control of buffalo fly and cattle tick in Queensland, and it is probable that the residual effect of the spray is an extremely important factor. Thus, in recent experiments all parasitic stages of the cattle tick were killed with one application of an emulsion containing 2 per cent. D.D.T., and this treatment prevented reinfestation for a period of about 12 days. Against the buffalo fly it was found that when each beast in a herd was sprayed with 2 per cent. D.D.T. emulsion on an area 12 in. $\times$ 18 in. on either side of the shoulders, adequate control of the flies resulted, although the treated hair did not remain toxic for as long on the living animal as on a piece of dead hide. Much work, however, still remains to be done in the selection of a satisfactory emulsion for application to animals, and in obtaining adequate proof that the D.D.T. does not harm them in any way.

Oils containing 5 per cent. D.D.T., and also emulsions, have been applied in spray form for the control of mosquito larvæ, since application of a liquid is often the most convenient way of dispersing a small amount of material uniformly over a large area. The D.D.T. is applied either from the ground by hand or power spray-guns, or from low-flying aircraft. As little as one to two quarts of oil solution is required per acre, which may be contrasted with the 18 to 20 gallons of oil often used per acre before the discovery of D.D.T. Oil solutions at one to two quarts per acre are used against the surface-feeding Anopheline mosquito larvæ, but are less effective against bottom-feeding Culicine mosquito larvæ, against which D.D.T. emulsions are used. Of the latter group of mosquitoes, the larvæ of the vector of dengue fever (*Aedes ægypti*) are killed under certain conditions by D.D.T. concentrations as low as one part in one hundred million parts of water. In direct contrast is the lack of effect of D.D.T. dusts, solutions, or emulsions upon the larvæ (or maggots) of flies, such as the Australian sheep blowfly (*Lucilia cuprina*) and the house fly (*Musca domestica*). The possibility of using D.D.T. against the sheep blowfly is still being examined, but it is clear that it will have to be employed against the adults, and not the maggots.

D.D.T. is ineffective against many species of mites attacking man and domestic animals.

The Toxicity of D.D.T. to Higher Animals and to Plants.

No instances of toxic symptoms in man have been recorded following the very extensive use of D.D.T. in the dry state, either as a 10 per cent. dust, or to impregnate clothing for the control of body-infesting insects. In experiments with laboratory animals, D.D.T. has been shown to be capable of absorption in toxic quantities through the skin from solutions or emulsions. It is desirable, therefore, to avoid prolonged skin contact with D.D.T. in these vehicles, particularly if the concentration

of D.D.T. is high. Little danger is expected from the occasional inhalation of fly spray, or from contamination of food by it.

The information at present available suggests that when D.D.T. is used on agricultural and horticultural crops for the control of pests it will not be any more dangerous to man than some insecticides now in common use, for instance lead arsenate and fluorine compounds.

Ingestion of comparatively large quantities of D.D.T. may lead to toxic symptoms or death in laboratory animals. It is desirable, therefore, to avoid excessive contamination of human food or eating utensils.

The permissible limit of food contamination has not yet been determined, but on present indications it appears that this limit may be set about seven parts per million.

D.D.T. poisoning affects the central nervous system and the liver, and the possibility of a cumulative effect has not yet been eliminated. It is for the latter reason that further work is necessary before it is safe to recommend the application of massive doses at regular intervals to animals, for instance, to cattle for the control of cattle tick or buffalo fly.

D.D.T. in the form of a dust mixed with pyrophyllite, talc or kaolin may be safely applied to crops with the exception of members of the cucurbit family, which have been found susceptible to injury. Aerosols developed for mosquito control are not suitable for application to crops, but a suitable mixture which has proved satisfactory during the last three years contains 5 per cent. each of D.D.T., cyclohexanone and lubricating oil (SAE 10), acetone 35 per cent., and methyl chloride 50 per cent. The acetone is phytotoxic, so care must be taken not to overdose crops. As already mentioned, some D.D.T.-white oil emulsions tested caused inhibition of growth in potted French bean seedlings in the glasshouse. The D.D.T.-solvent naphtha emulsion already mentioned appears quite safe to use on crops.

References.

Owing to lack of space, it is not possible to list the many references to published and unpublished work which have been drawn upon for the present article. Results of C.S.I.R. experiments will shortly commence to appear in C.S.I.R. publications. References to all articles published on D.D.T. up to April, 1944, are given by Roark (Roark, R. C., U.S.D.A., June, 1944), and a supplementary list includes all publications up till December, 1944 (Roark, R. C., U.S.D.A. E660, May, 1945). A great deal of information has been published in the *Journal of Economic Entomology*, particularly the February, 1944, and April, 1945, issues. These sources should be consulted by those desiring detailed information.

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Production of Lactic Acid

I. FROM WHEY

By

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Wartime shortage of imported citrates and tartrates[2] has recently stimulated the production in Australia of lactic acid as a substitute acidulant for the food industries. Several workers have outlined the fermentation processes used both here[1, 7, 11] and overseas.[3] Despite bacteriological and chemical control, it frequently happened that fermentations took more than five days instead of two days, contaminants were troublesome and yields of lactic acid were poor.

The object of the investigations described in the present paper was to find the optimum conditions for the development of the lactobacilli and to discover ways of accelerating the fermentation.

Experimental Technique.

Whey for experimental purposes was obtained from a commercial casein plant. The sugar content was adjusted to 4·5 to 5·0 per cent. by the addition of lactose, and 4·0 per cent. of precipitated calcium carbonate was added as a neutralizing agent. The mixture was pasteurized at 70° C. for half an hour, cooled to 48° C., inoculated with 10 per cent. of a 24-hour old starter of *Lactobacillus bulgaricus*, strain 13, incubated at 48° C. and shaken thrice daily unless stated otherwise. The percentages of substances undergoing tests as fermentation stimulants were expressed as gm. of dry material per 100 ml. of mixture. The fermentation vessels were deep and usually contained 200 ml. of media, but tests involving expensive vitamins and amino acids were carried out in test-tubes containing 20 ml. Five-litre lots were used for semi-pilot-plant work, and commercial vats containing 5,000 gal. were used in the final stages. All treatments were replicated at least twice. The fermenting mixtures were examined microscopically on the second day of incubation as a check on purity of the cultures.

At first the course of the fermentation was followed by daily determinations of lactic acid[5] produced and lactose[11] consumed until less than 0·1 per cent. of sugar remained. These laborious analyses were eliminated after it was found that lactose consumption closely paralleled acid production and that usually 98 per cent. of the acids formed were lactic. Titratable acidity was determined by the following method, despite the presence of excess calcium carbonate.

Fermentation vessels were shaken vigorously and while the calcium carbonate was still in suspension 10·0 ml. aliquots were quickly pipetted into 8·0 ml. of N H_2SO_4 in 100 ml. flasks. These were placed in a steamer for 10 minutes to liberate the carbon dioxide. Calcium sulphate was formed and the free lactic acid was titrated against N NaOH using phenolphthalein as indicator. Titratable acidity was expressed as mls. of N. lactic acid per 10 ml. of medium. One-tenth of the above reagents was used for test-tube fermentations and when over 4·0 per cent. of calcium carbonate was employed the volume of N H_2SO_4 was increased in proportion. This rapid method proved to be quite accurate, duplicate determinations on the same treatment agreeing to within 0·03 ml. The use of calcium carbonate was preferred to that of the usual phosphate buffers as it approximated to commercial conditions and the progress of the fermentation could be followed from beginning to end.

Factors Influencing Fermentation.

Yeast Additions. At an early stage in the work it was found that the addition of dead yeast cells to whey greatly stimulated the fermentation. Figure 1 shows that with 0·3 per cent. of yeast all the lactose was consumed within two days, whereas in the control the reaction was not complete even after six days. Concen-

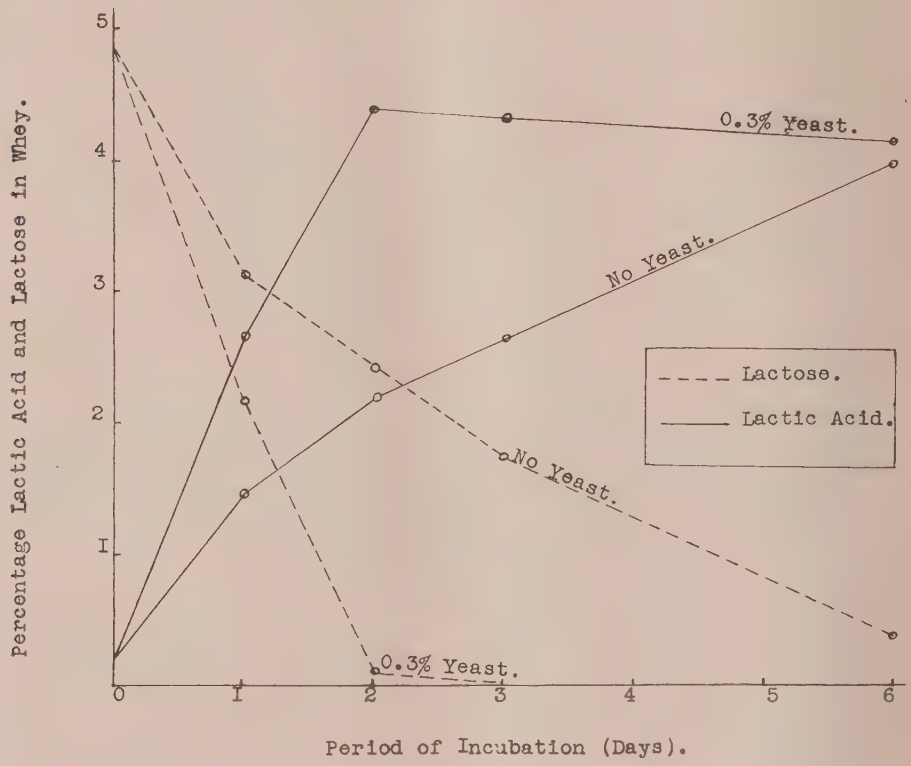

Figure 1.
Rate of Lactic Acid Production and Lactose Consumption in the Presence and Absence of Yeast.

trations of yeast above 0·3 per cent. stimulated the fermentation still further, the optimum being 0·4 per cent., which completed the process in one and a half days. In all subsequent experiments this treatment was included as a reference standard for a rapid fermentation.

The addition of 150 lb. of compressed bread yeast to 5,000 gal. commercial vats reduced the period of fermentation from five to two days, but the expense was so heavy that other methods were sought for accelerating lactic acid production.

Incubation Temperature. Fermentations were conducted at incubation temperatures ranging from 38° C. to 52° C. Lactic acid formation increased rapidly from 38° C. to 48° C. then declined slightly. Contaminants were less troublesome as the temperature was raised from 38° C. to 52° C. Even at the optimum temperature of 48° C. the fermentation was never completed in less than five days, except in the presence of yeast.

Reaction. If lactic acid were allowed to accumulate in sterile neutralized whey in the absence of calcium carbonate the rate of production of acid and multiplication of *L. bulgaricus*, 13, progressively declined until pH 4·0 was reached, when growth almost ceased. In pasteurized whey contamination was rarely noticed below pH 5·0, it was slight between pH 5·0 and pH 5·8, while above pH 5·8 it was troublesome.

Fermentations, relatively free from contaminants, were obtained industrially by maintaining the pH of the vat between 5·0 and 5·8 either by the intermittent addition of hydrated lime slurry, or by the use of excess calcium carbonate kept in suspension by gentle stirring. Violent agitation must be avoided as it leads to frothing and excessive aeration.

Aeration. Slow bubbling of air through fermenting whey to raise the redox potential did not check anaerobic butyric and proteolytic contaminants without harming the microærophilic lactobacilli. (*cf.* 4, 12) The best results were obtained when air merely diffused into the surface layers of the whey. The exclusion of oxygen with a paraffin seal or the addition of thioglycollic acid as a reducing substance also inhibited *L. bulgaricus*, 13.

Starter. It is the usual practice to start a fermentation with 10 per cent. of a 24-hour old culture of *L. bulgaricus*. Tests using different amounts of starter varying between 2 and 15 per cent. showed that the larger the quantity added the shorter the time of fermentation, but little was gained by increasing the amount above 10 per cent. Greater numbers of lactobacilli and consequently slightly shorter periods of fermentation were obtained by adding 0·1 per cent. of yeast, and also calcium carbonate to the starter to neutralize the acid formed during incubation.

Pasteurization. Contamination might conceivably be better controlled if the whey were pasteurized at higher temperatures or for longer periods than at 70° C. for half an hour, although such treatments might adversely affect the fermentability of the whey. Pasteurization temperatures varying from 70° C. to 100° C. for periods ranging from one-half to five hours were tested. Very little contamination was experienced under laboratory conditions with any of the treatments, and the periods of fermentation were not affected. Severe methods of pasteurization, however, caused greater heat coagulation of lactalbumen and under commercial conditions this sludge of protein settled to the bottom of the vats and harboured objectionable proteolytic contaminants. Coagulation was minimized when the whey was heated directly by bubbling steam into the vat rather than indirectly by using heating coils. Boiling and filtering the whey to remove lactalbumen made no difference to the period of fermentation, indicating that sufficient amino acids were available.

Type of Whey. An experiment was designed to find whether the method of preparation of whey might influence its chemical composition and thus affect its rate of fermentation. The fermentability of whole-, skim- and butter-milk was compared with whey prepared from them by precipitating the casein with either lactic acid, rennin or various bacteria including *Streptococcus cremoris*. There was no significant difference in the times of fermentation of the various wheys or milks, thus suggesting that these media were unsatisfactory for rapid growth of *L. bulgaricus* without the addition of yeast. This is not surprising since *L. bulgaricus* is rarely found in nature except in association with yeasts and other microorganisms.

Batch Process. Whittier and Rogers[13] described a continuous fermentation process and claimed that most of the lactose disappeared after 24 hours. Experiments in this laboratory showed, on the contrary, that even in the presence of yeast considerable amounts of sugar remained which subsequently interfered with the crystallization of calcium lactate. For this reason the batch method was preferred to the continuous process.

Lactate Inhibition. There is a marked decline in the rate of acid formation towards the end of the fermentation, possibly due to the accumulation of dissolved

lactates. The initial concentration of calcium lactate was varied between 0 and 6·0 per cent., and it was found that six to nine days respectively were required to complete the fermentation. When yeast was present these times were reduced to one-third.

Fermentable Carbohydrates. Sometimes the lactose content of whey is rather low, so that it is not economical to produce calcium lactate unless the sugar is augmented. Strain 13 of *L. bulgaricus* is slightly atypical since it readily ferments lactose, sucrose, maltose and glucose. Increasing the concentration of fermentable carbohydrates up to 9 per cent. by the addition of cane sugar, molasses, enzyme- or acid-hydrolysed wheat starch unduly prolonged the fermentation except in the presence of yeast, when it was completed rapidly within two or three days. On the other hand malt extract without yeast stimulated the lactobacilli so that the process was over in three days.

The foregoing experiments showed that by using optimum physical conditions contamination problems certainly could be minimized, but that little could be done to complete the fermentation in less than five days unless yeast or malt extract were added.

Other Sources of Stimulants. Cheaper substitutes for yeast were sought which might be used industrially. The number of days required to complete the fermentation of whey containing 0·4 per cent. of various sterile cellular materials is given in Table 1.

TABLE 1.

Influence of Various Cellular Materials on Period of Fermentation.
Figures show days required to complete fermentation.

Material.	Days.	Material.	Days.
Bread yeast (*S. cerevisiæ*)	2	Sheep heart	3½
Beer yeast (bottom) (*S. cerevisiæ*) ..	2+	Burr medic (*Medicago denticulata*)	3½–4
Wine yeast (*S. ellipsoideus*) ..	2½	Prairie grass (*Bromus unioloides*)	3½–4
Film yeast (*Candida krusei*) ..	2½	Germinated wheat	4
Human fæces	2½	*L. bulgaricus*, 13 (dead)	5
Sheep liver	2½	*Rhizobium leguminosarum* ..	5
Malt sprouts (barley)	2½–3	Vegemite	5
Malt extract (barley and wheat) ..	3	Wheat bran	6
Malted barley	3½	Untreated	7
Malted wheat	3½		

It will be seen that the various yeasts, fæces and liver were excellent sources of stimulants, resulting in the completion of the process in 2 to 2½ days. Malt sprouts and extract gave good results while the poorest source, wheat bran, was almost useless. The only material which could be readily obtained for commercial purposes was malt sprouts. When the optimum of 4·0 per cent. was used, the process was finished within 2½ days but unfortunately this bulky material interfered with subsequent decantation and filtration and occasionally introduced contaminants.

The Nature of the Stimulants.

An attempt was made to discover the chemical nature of the stimulants present in various yeasts and other cellular products.

Minerals. Neither the ash of yeast nor various concentrations and combinations of major and minor elements in the form of di-potassium phosphate, sodium hexameta-phosphate, calcium glycerophosphate, sulphates of magnesium, iron, manganese, copper and zinc, potassium chloride, sodium diborate and sodium molybdate appreciably accelerated the rate of lactic acid production.

Nitrogenous Substances. The weak proteolytic activity of *L. bulgaricus*, [8] prompted a trial of different nitrogenous substances as possible stimulants. Ammonium salts, nitrates, urea, pepsin-, trypsin- and acid-hydrolysed gluten, serum albumen, lactalbumen, casein and gelatine were ineffective ; various meat-hydrolysates gave slight stimulation, 0·5 per cent. of Gideon-Richter peptone reduced the period of fermentation to two days, and 0·4 per cent. of autolysed bread yeast reduced it to one and a half days. In general, impure proteid materials, which doubtless contained other cell constituents besides amino acids, gave better results than purer proteins. Enzymatic digests were superior to H_2SO_4—hydrolysates thus indicating some destruction of the stimulating substances by high acidity or high temperatures.

Eleven crystalline amino acids were tested in various concentrations, singly and in numerous combinations. Summarizing the results, leucine, aspartic acid, asparagine, glutamic acid, histidine and proline gave no stimulation ; glycine, β-phenylalanine and tryptophane caused very slight improvement in rate of fermentation ; α-alanine, cystine and tyrosine gave fair results ; and the best results were obtained with a mixture containing 0·02 per cent. of each of the last-mentioned six amino acids. These, however, only reduced the period to four and a half days. Other amino acids were not available for trial but it was considered that most of these would have been present in the protein digests previously tried and found to be only slightly beneficial.

Apparently substances other than amino acids, possibly degradation products of nucleo-proteins, were responsible for the activation of the lactobacilli. Uracil, adenine, xanthine, guanine, creatine, pyridine, thymus nucleic acid and a H_2SO_4-hydrolysate were tested but they caused no acceleration.

Vitamins and Hormones. The vitamin requirements of lactobacilli[9] are complex, but little is known concerning the specific needs of *L. bulgaricus*. Whey fermentations were carried out using various concentrations and combinations of thiamin, riboflavin, nicotinic acid, biotin, i-inositol, calcium pantothenate, p-aminobenzoic acid, ascorbic acid, α-naphthalene-acetic acid, shark-liver oil concentrate of vitamins A and D. None of these treatments stimulated lactic acid production appreciably. A combination of 5·0 mg. per cent. of thiamin and riboflavin together with the above-mentioned six amino acids reduced the period of fermentation to four days.

It was thought possibly that *L. bulgaricus* might be incapable of synthesizing co-enzymes in sufficient amounts for its optimum growth. Co-zymase, co-carboxylase and muscle adenylic acid were therefore tried but with very little benefit.

Vitamins such as pyridoxine and folic acid were unobtainable and could not be tested, so it is possible that they may have been the essential substances missing from whey but present in yeasts, peptone malted grains, etc.

Properties of Stimulants. It was found that the stimulants were readily released after autolytic or enzymatic digestion of yeasts but could be leached out only partially with hot or cold water, acids or alkalis. Very little was extracted with ether after 48 hours under acidic, alkaline or neutral conditions. They were stable to autoclaving for 20 minutes at 15 lb. pressure even in the presence of N H_2SO_4 or N NaOH but digestion with 9N H_2SO_4 destroyed much of their activity.

Production of Stimulants by Mixed Cultures.

Though the nature of the growth factors remains unknown, natural methods for producing them with microorganisms growing in the whey vats were explored.

Film Yeasts. Attempts were made to cultivate lactose-fermenting yeasts in whey at 30° C. prior to fermenting with *L. bulgaricus* at 48° C., but this failed because contaminants overwhelmed the yeasts. Several film yeasts or mycoderms, imported from overseas or isolated locally from whey vats and brewers' grains, withstood temperatures as high as 42° C. Some of these, particularly *Candida krusei*, greatly stimulated the growth of *L. bulgaricus*, 13, when grown in association so that the fermentation was concluded in two to three days. This method worked well in the laboratory, but in large-scale trials contaminants occasionally multiplied at the low temperature and produced fairly large quantities of acetic acid. Dead mycoderm cells also stimulated the lactobacilli to divide rapidly but the greatest response resulted from the use of live or autolysed cells.

Strains of Lactobacilli. Various species of *Lactobacillus* were tested, including *L. bulgaricus*, *L. thermophilus*, *L. lactis*, *L. helveticus* and *L. casei* but it was soon found that *L. bulgaricus* was the most suitable as it produced the greatest amount of lactic acid and it was the only species which survived repeated subculturing in whey at 48° C. without the addition of yeast. Numerous strains of *L. bulgaricus* were

imported and isolated locally from dairy products. It was observed that they could be divided into short- and long-celled strains and that in general the former types completed the fermentation in four to five days, while the latter took longer. All strains greatly benefited by the addition of yeast.

When the investigation had reached this stage it was learned from Pont and Maxwell[8] that they had succeeded in shortening the fermentation time to $2\frac{1}{2}$ to 3 days by using a mixture of three strains of *L. bulgaricus*, containing two large-celled types, namely V8 and L.B.3, and one small-celled strain, B. Usually short-strain B predominated. Their work was confirmed and furthermore it was noted that addition of yeast caused the long-celled types to predominate. In an effort to find which of the strains was stimulatory, the three types were used singly, in all possible pairs,

TABLE 2.

Influence of Different Combinations of Strains V8, LB3 and B on Period of Fermentation.

Strains.	Days Required to Complete Fermentation.
V8	>6
LB3	>6
B	4
V8+LB3	6
V8+B	3
LB3+B	$2\frac{1}{2}$+
V8+LB3+B	$2\frac{1}{2}$

and together. The results appear in Table 2. Whenever strain B was present in the inoculum the fermentations were always faster than when it was absent. Various combinations of other short- and long-celled strains of *L. bulgaricus* were tried and in general mixtures containing all short- or all long-types performed poorly, while combinations of small- and large-celled strains gave quicker fermentations. Short strains usually outnumbered associated long ones except in the presence of yeast. It was found that dead cells of short strains stimulated live long types, and *vice versa*, but not to the same degree as live cells. Many mixtures of *L. bulgaricus* produced substances resembling diacetyl which persisted in the purified lactic acid, but suitable combinations of short- and long-types were selected which gave $2\frac{1}{2}$-day fermentations without undesirable odours.

Under commercial conditions the correct balance was maintained between the numbers of short- and long-lactobacilli by preparing separate starters, or by using mixed starters containing small quantities of boiled yeast or malt sprouts which shortened the fermentation to less than two days.

Summary.

The investigation dealt with the optimum conditions for the fermentation of whey with *L. bulgaricus*. These included temperature of incubation, pH, degree of aeration, amount of starter and method of pasteurization. The influence of type of whey, concentration of lactate and fermentable carbohydrates were also studied. A continuous method was found to be inferior to fermentation in batches. Careful control of the process minimized contamination but did not reduce the period of fermentation below five days. Addition of bread yeast to the whey decreased this time to $1\frac{1}{2}$ days by stimulating the rate of multiplication of lactobacilli, while other cellular materials were less effective. The stimulants could not be replaced by

additional minerals, various nitrogenous substances or vitamins, although treatment with a mixture of thiamin, riboflavin and six amino acids was slightly beneficial. The growth factor in yeast was not identified but some of its properties were determined.

The fermentation was accelerated by growing *L. bulgaricus* in association with a film yeast at 42° C. Under commercial conditions, however, contamination was a problem at this low temperature and better results were obtained at 48° C. with mixed starters containing short- and long-celled strains of *L. bulgaricus* which took 2 to 2½ days even in the absence of yeast.

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Production of Lactic Acid

II. FROM WHEAT STARCH

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The production of lactic acid by fermentation of whey was dealt with in a previous paper.[1]

The supply of whey for lactic acid production is subject to seasonal fluctuations, so that industrial plant is often idle during the winter. Since wheat starch is readily obtained the whole year round, experiments were conducted to find the best method of utilizing it.

Experimental Technique. The technique previously used for whey was adopted for the research on wheat starch. Usually *L. delbrueckii*, strain T, was used as well as *L. bulgaricus*, 13. The amount of starch in the medium was calculated as 0·90 times the difference between the amounts of reducing sugar present in the filtered medium before and after 2½ hours hydrolysis in N HCl at 100° C. Laboratory processes were retested in commercial vats.

Results of Experiments.

Strains of Lactobacilli. The relative efficiencies of *L. bulgaricus*, 13, and strains of *L. delbrueckii* imported from overseas or isolated locally from malted grain mashes were determined in a medium containing 13 per cent. malt extract (10 per cent

reducing sugar), 1·0 per cent. peptone and 6 per cent. calcium carbonate *L. bulgaricus*, 13, gave the quickest fermentation, which ended in two days, the best strain of *L. delbrueckii*, namely T, took $2\frac{1}{2}$ days, while the slowest required five days.

Fermentation of Acid-hydrolysed Starch. Ten per cent. gels of wheat starch in 0·1 N H_2SO_4 were hydrolysed by autoclaving for one hour at 22 lb. pressure. Preliminary tests showed that this mixture was unsuitable as a medium for *L. bulgaricus*, 13, or *L. delbrueckii*, T, unless additional nitrogen, growth factors and minerals were provided in the form of peptone, dried yeast, K_2HPO_4 and $MgSO_4$ (Table I).

TABLE I.

Influence of Peptone, Yeast and Minerals on Period of Fermentation of Wheat Starch Hydrolysate.

Treatment.*	Days Required to Complete Fermentation.	
	L. bulgaricus, 13.	*L. delbrueckii*, T.
Peptone	10	12
Yeast	7+	8+
Minerals	>12	>12
Peptone+Yeast	$3\frac{1}{2}$	4
Peptone+Minerals	9	10
Yeast+Minerals	8	8
Peptone+Yeast+Minerals ..	$2\frac{1}{2}$	$2\frac{1}{2}$

* Peptone, 0·5%; Yeast, 0·4%; Minerals, K_2HPO_4, 0·2% and $MgSO_4$, 0·02%.

Later it was found that the addition of 4·0 per cent. boiled malt sprouts alone enabled the process to be completed in three days. Neither whole meal nor white flour hydrolysates responded to the addition of peptone or minerals, presumably because sufficient amino acids and minerals were not lacking, but with the addition of yeast the fermentation was completed in 3 to $3\frac{1}{2}$ days. However, both flours were unsuitable because the large quantities of gluten and fibre interfered with decantation and filtration of the calcium lactate solution. These were best precipitated under highly alkaline conditions induced by over-liming.

As high pressure acid-hydrolysis of starch was considered to be too expensive, work was conducted on enzymatic saccharification.

Fermentation of Enzyme-hydrolysed Starch. A slurry containing 10 per cent. starch and 2 per cent. malt sprouts was boiled with a small amount of H_2SO_4 to reduce the viscosity of the gel. After adjusting the pH to 5·0 by the addition of excess calcium carbonate it was cooled and inoculated with mycelium of *Rhizopus delemar*. After aerating for two days at 37° C. the mould had converted all the starch to glucose and the mixture was boiled prior to inoculation with *L. bulgaricus*, 13, or *L. delbrueckii*, T. The fermentation took $2\frac{1}{2}$ days, so that a total of $4\frac{1}{2}$ days was required for the whole process. This was too long.

Much time was saved and contamination was better controlled by conducting both the saccharification and fermentation simultaneously. A starch solution was

prepared as previously, but instead of adding *Rhizopus delemar* it was cooled to 60° C. and 2 per cent. of untreated malt sprouts or germinated wheat, as a source of amylolytic and proteolytic enzymes, was stirred in together with 10 per cent. starter of *L. bulgaricus*, 13, or *L. delbrueckii*, T. Both species of *Lactobacillus* completed the process in 2½ to 3 days. Despite the use of non-sterile raw materials, no contamination problems arose under laboratory conditions provided the pH was maintained between 4·8 and 5·4 and the temperature at 50° C. In a commercial plant this method failed because contaminants often gained the upper hand.

Final Process. The method finally adopted was to mix medium quality white flour with water to make a dough ; from this the starch, minerals and water-soluble proteins were washed free in a starch washing machine, leaving most of the gluten adhering to the paddles. The washings containing 10 to 12 per cent. of starch were subjected to mild acid-hydrolysis in the fermentation vats by boiling with 0·2 N H_2SO_4 for three hours, then adjusting the pH to 5·4 with calcium hydroxide prior to adding the starter. This treatment sterilized and hydrolysed the mixture without decomposing all the growth factors or seriously harming the wooden vats. Tests were carried out to find whether mixed inocula of short- and long-celled strains of *Lactobacillus* and mycoderms hastened the fermentation of this medium. The results showed that at 48° C. *L. bulgaricus*, 13, and *L. delbrueckii*, T, each completed the fermentation in 3 days, while mixtures containing *L. bulgaricus*, strains 13 and B, or V8, L.B.3 and B took 2½ days. At 42° C. in the presence of the mycoderm, *Candida krusei*, fermentations finished within two days, but occasionally rather large amounts of acetate occurred.

Summary.

Strains *L. bulgaricus*, 13, and *L. delbrueckii*, T, were unable to ferment acid-hydrolysed wheat starch unless extra minerals, amino acids and vitamins were added. Malt sprouts or germinated wheat were able to supply all these deficiencies. The method of first saccharifying starch with *Rhizopus delemar* and subsequently fermenting it required 4½ days and increased the chances of contamination. When starch was hydrolysed with unheated malt sprouts or germinated wheat and simultaneously fermented, the reaction took 2½ to 3 days, but contaminants were difficult to suppress.

The practice finally adopted was to hydrolyse and sterilize the starch medium by boiling for 3 hours with 0·2 N H_2SO_4 then fermenting for 2½ days at 48° C. with a mixed inoculum of short- and long-celled strains of lactobacilli, or 2 days at 42° C. in association with a mycoderm.

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Technical Notes

RELIABILITY OF RAIN IN AUSTRALIA AS COMPARED WITH THE REST OF THE WORLD.

Most Australian agriculturists are familiar with the high variability of rain in many parts of the continent ; and many of us have come to think of this as a peculiarly Australian problem. The purpose of this note is to call attention to a study by Conrad[1] in which the rainfall variability of the world is mapped in a new and interesting way. This map supplements the world variability map of Biel[2] which appeared in a students' paper and in which the values for Australia were apparently invented from no more information than the average rainfall.

Conrad starts from the familiar principle that on the whole the lower the rainfall the less constant it is. He calculates the mean deviation from the mean for each station and records this as a percentage of the mean ; thus Bourke has a mean of 13·6 inches, a mean deviation of 4·7 inches, and therefore a variability of 36 per cent. He then draws a hyperbolic graph which gives the best fit to all his pairs of figures for rainfall and variability through the world. The following values are taken from his tables. Presumably Biel used some such table in computing his values for Australia.

Average annual rainfall, inches	5	10	15	20	30	60
Expected percentage variability	31	24	20	18	17	15

Conrad now arranges his stations according to how much the variability differs from that predicted from the tables. Thus Bourke, with 13·6 inches, would be expected to have a percentage variability of about 21 per cent. The actual variability is 36 per cent., so Bourke appears as +15, being far more erratic than most other places of the same mean rainfall.

Conrad's map of the world shows that the whole of Europe, most of North America, and Asia north of latitude 40° are more reliable than the world average, and that the three regions that are the most erratic for a given rainfall comprise two desert belts—the coast of Chile and Peru and a belt from Khartoum to Karachi—and the monsoonal north-east of Brazil, where Recife with 55 inches has a variability more than twice the expected value of 15 per cent.

How does Australia appear on this basis ? Conrad's treatment is meagre, but the main features can be seen by a few calculations. The only section that has a variability *less* than the standard value is the winter-rain region south of a line from Geraldton to Port Augusta, thence to the head of St. Vincent Gulf, to Swan Hill, and thence to Gabo Island. This includes the wheat-belts of three States except for the " northern " areas in South Australia, which, however, come very close to inclusion ; thus the dry margins of the wheat belt, erratic as they are, are no worse than should be expected for rainfalls between 10 and 15 inches. Some coastal districts in this winter-rain region are remarkably reliable : Portland with 33 inches has a variability of only 7 per cent. ; no other town in Conrad's world records has a lower variability than this.

On the other hand, all our summer-rain regions are more erratic than the tables predict. The pastoral belt with 15-25 inch rainfall running north and west from central New South Wales through Queensland and the Northern Territory has scores from +10 to +20 above normal, and appears to be more unreliable than any large region of similar rainfall in the world. The Riverina is transitional from the " normal " to the " abnormal ". The whole of monsoonal Australia is notably

erratic, as was well brought out by Prescott[3] in his comparison of northern Australia with northern Nigeria. A typical monsoonal figure is Daly Waters with 25 inches, 28 per cent. variability, or +10 over the world norm. These figures contradict Barkley's[4] widely-quoted map, which by taking district, instead of station records, seriously underestimates variability, especially in the Northern Territory. (Barkley uses percentage *standard deviation*, which is roughly 5/4 times the *mean deviation*). Griffith Taylor's map[5] using mean deviation per cent. over a 20-year period, is much to be preferred. The notorious Onslow, with its variability of 61 per cent. against the expected 25 per cent., appears as +36, which exceeds all Conrad's values except Malden Island in the Pacific Ocean. (The similarly situated Ocean Island, not quoted by Conrad, is a rival to Malden Island.)

The approach to the problem as recorded here is obviously crude. "Mean deviation per cent. of annual mean" is not a particularly good way of measuring rainfall variability; it is quick and simple and evidently that is why Conrad used it. Further, Conrad has weighted Europe and North America too heavily in deriving his formula. But while a statistician could compute indices that would be more useful in practice than this one, and while more refined measurements of variability are most desirable, there is little doubt that the differences noted here between Australia and other countries would reappear with other methods of calculation.

I am indebted to Dr. F. Loewe, of this University, for bringing this work to my notice, and to Mr. H. R. Arthur for many of the calculations.

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DIAPAUSE IN *SCELIO CHORTOICETES* FROGG. (SCELIONIDÆ), A PARASITE OF THE EGGS OF *AUSTROICETES CRUCIATA* SAUSS.

During the examination of some thousands of eggs of the Australian plague grasshopper *Austroicetes cruciata* Sauss., collected from Wilmington and Orroroo in South Australia in 1940, the writer was able to segregate a small percentage of eggs which had been parasitised by *Scelio chortoicetes* Frogg. These were distinguished from unparasitised eggs by the absence of the eyespots of the grasshopper embryo, which are visible macroscopically in unparasitised eggs from an early stage of development. Experiments carried out with parasitised eggs showed that the parasite has a larval diapause which enables its life history to synchronise with that of its host.

The development of the eggs of *A. cruciata* is arrested in the spring shortly after the eggs have been laid; this diapause continues until about mid-June.[3] At Wilmington at the end of April, 1940, nearly all the parasitised eggs contained a first stage larva; a few parasites were in the pupal stage. Between May and July, a few adults emerged from eggs in the field, but most of the parasites remained as first

stage larvæ until September. By mid-September, when most of the grasshoppers had hatched, most of the parasites were pupæ. The time of emergence of the adult wasps is not known, but in November when the grasshoppers have reached maturity, the wasps are readily observed flying around ovipositing females, awaiting the first opportunity to parasitise the newly-deposited eggs.

A batch of 40 eggs containing first stage larvæ of the parasites was collected from Wilmington in March and incubated at 30° C. for four months, but no wasps emerged from these eggs. A batch of 80 eggs was collected in mid-June ; 40 of these were incubated at 30° C., wasps emerged from all these eggs in 42 days ; the other batch of 40 eggs was exposed to low temperatures, 8° C. and 13·5° C. on alternate days for 18 days ; on incubation at 30° C. adult wasps emerged from these eggs in 18·5 days.

The failure of the parasites to develop in eggs collected in March when incubated at 30° C. indicates a diapause in the first stage larva. The slow rate of development of the parasites collected in mid-June indicates that the diapause had not been completely eliminated by that date. The speeding up of development following the exposure to low temperatures suggests that low temperatures are responsible for the elimination of diapause in the parasite, as is the case with the embryo of the host.[1] The parasite remains in diapause for a longer period than the grasshopper embryos in which diapause is eliminated by mid-June. This is associated with the fact that the parasites emerge at a later date than the grasshoppers.

Parasitised eggs are more resistant to desiccation than non-parasitised eggs. Eggs containing first stage larvæ of *Scelio* collected in March remained turgid after six weeks' desiccation over concentrated sulphuric acid at 13·5° C. At the end of this period the eggs contained 66 per cent. water, which is about the average water content of unparasitised eggs collected from the field in March. The parasites were still alive. This resistance to water loss is probably associated with the absence of the developing grasshopper embryo, as it has been shown that the egg loses water more readily as the grasshopper embryo develops.[4]

The first stage larva resembles in general structure that of *Scelio fulgidus*.[6] A prominent cephalothorax bears short antennæ and a pair of curved mandibles. Anteriorally the abdomen bears a row of setæ on the dorsal and lateral areas. The abdomen terminates in an appendage which is bifid at the end. The mouth is ventral and the alimentary canal blind. The second stage larva is grub-like, segmented and the alimentary canal appears to be blind, at least in the early stages.

The existence of mouth parts in the first stage larva suggests that it feeds on the young grasshopper embryo. Its failure to develop further until the eggs have been subjected to low temperatures suggests that the remaining material in the egg, which is mostly yolk, is unsuitable for the nutrition of the parasite until it undergoes some changes which depend on low temperatures. This is the explanation of diapause and its elimination given by Andrewartha[1] for the egg diapause of the host grasshopper.

With hosts that have a diapause, the existence of a diapause in their parasites would seem to be a necessary factor for successful parasitism. The synchronisation of the life cycle of the parasite with the specialised life cycle of such hosts by means of diapause has been observed with a number of parasitic hymenoptera.[5]

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INFLUENCE OF YEAST EXTRACT ON *LACTOBACILLUS BULGARICUS* INCUBATED AT VARIOUS TEMPERATURES.

Stern and Frazier[1] stated that at 37° C. *L. bulgaricus* multiplied continuously throughout the period of fermentation, and this was closely paralleled by lactic acid production, but at 49·5° C. these relationships did not hold. At 49·5° C. it was claimed, bacterial growth ceased shortly after the start of the experiment, although acid continued to be formed by the enzymes.

Fermentations were conducted at temperatures between 30° C. and 49° C. in autoclaved, filtered whey containing 4·0 per cent. of calcium carbonate in the presence and absence of 0·4 per cent. Difco yeast extract. Titratable acidity and cell turbidity measurements were made at daily intervals on 10 ml. aliquots treated with 8·0 ml. N HCl to decompose the calcium carbonate and calcium lactate. The results are shown in Tables I and II. It is apparent that yeast extract encouraged

TABLE I.

Influence of Temperature on Acidity and Turbidity in the Presence of 0·4 per cent. Difco Yeast Extract.

Hours of Incubation.	Temperature of Incubation.							
	30° C.		37° C.		43° C.		49° C.	
	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.
0	0·20	30·0	0·20	30·0	0·20	30·0	0·20	30·0
18	0·38	28·0	0·72	13·5	3·06	6·25	2·87	7·0
24	0·45	27·5	0·98	11·0	4·20	5·5	3·85	6·0
40	0·54	14·0	2·86	7·0	4·71	5·0	4·74	5·5
48	0·74	11·5	3·29	6·5	4·75	5·25	4·72	5·0
65	1·56	9·75	4·25	6·75	4·70	5·25	4·72	5·0
Hours Required to Complete Fermentation and to Reach Maximum Turbidity	>65	65	>65	48	40	40	40	48

TABLE II.

Influence of Temperature on Acidity and Turbidity in the Absence of Yeast Extract.

Hours of Incubation.	Temperature of Incubation.							
	30° C.		37° C.		43° C.		49° C.	
	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.	Titratable Acidity.	Index of Turbidity.
0	0·20	30·0	0·20	30·0	0·20	30·0	0·20	30·0
18	0·34	29·0	0·36	23·0	1·40	10·5	1·35	10·0
24	0·37	28·5	0·18	20·0	2·83	8·25	2·62	8·5
40	0·41	27·0	1·20	12·5	4·08	7·25	3·97	7·5
48	0·45	26·5	1·82	9·0	4·47	7·0	4·50	7·25
65	0·49	25·75	3·03	8·5	4·59	7·0	4·64	7·25
Hours Required to Complete Fermentation and to Reach Maximum Turbidity	>65	65	>65	65	65	48	65	48

greater cell growth and lactic acid production at all temperatures of incubation. Contrary to the results obtained by Stern and Frazier, the greatest stimulation occurred at the higher temperatures of 43° C. and 49° C. and not at the lower temperature of 30° C. and 37° C. No cessation of bacterial reproduction was observed at the higher temperatures, for in all cases the turbidity increased (index decreased) until all the lactose was consumed when cell multiplication ceased. Yeast evidently supplied *L. bulgaricus* with some essential metabolites which were lacking in whey. The resultant larger cell population probably caused the quicker formation of lactic acid.

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TENSION OF WATER IN A SANDY SOIL AT FIELD CAPACITY.

Records of fluctuations in the tension of water in irrigated sandy soils near Waikerie, South Australia, during two irrigation seasons have been kept by the Horticultural Branch of the Department of Agriculture. Four tensiometers of a type described recently[4] were placed at depths of 18 inches and 36 inches in two adjacent plots and readings were taken at intervals of either two or three days. Vines growing on the site were in a weak condition and were drawing little water from the soil. Because of this, steady tensions were noted for some time after some of the irrigations and it was possible to draw conclusions concerning the relation of tension to field capacity. The soil was a deep sand (Winkie sand) with the properties shown in Table I. Periodical moisture samples from a depth of four feet showed that the soil was well drained.

Table I.

Mechanical Analyses and other Data for a Winkie Sand Profile near the Experimental Site.

Depth (inches)	0–12"	12–32	32–78
Texture	Sand.	Sand.	Sand.
	%	%	%
Coarse sand	63·9	54·3	53·3
Fine sand	30·8	39·7	41·1
Silt	0·9	0·7	0·9
Clay	3·9	4·7	3·9
Loss on acid treatment	0·4	1·0	1·2
Moisture equivalent	2·9	—	—
Total soluble salts	0·015	0·015	0·015
Chlorides (Cl)	0·003	0·009	0·003

After each irrigation the tension fell immediately at both depths. On three occasions the increase during the period between the second and tenth day following the irrigation was only slight, although later the tensions rose to values as high as 800 gm. cm./gm. Means of four readings taken every second or third day during this steady period are recorded for each tensiometer in Table II. The general mean for the four tensiometers at both plots and at both depths after all three irrigations is 71 gm. cm./gm. This tension is equivalent to a 71 cm. column of water. It may also be expressed as a pressure potential of -70×10^3 ergs/gm. or a pF of 1·85. The term pF is however of doubtful application in this case.[3]

TABLE II.

Mean Tensions for Three Periods of Steady Tension following Irrigations.

Plot.	Depth.	Field Capacity.	Mean Tensions.
	Inches.	%	Gm. cm./gm.
B	18	4·6	64, 85, 62
	36	4·8	60, 50, 65
C	18	5·8	75, 87, 87
	36	6·3	69, *, 75

* A rapid increase in tension followed this irrigation.

This value for tension at field capacity is very low in comparison with that of pF 3 (1000 gm. cm./gm.) which is usually given.[1] The value pF3 was originally suggested by Schofield[7] for the free energy of soil water at field capacity on the basis of the approximate equality of water contents at field capacity and at moisture equivalent. It has, however, been shown by Bodman and Day[3] that a large part of the free energy (or total moisture potential) of water at the moisture equivalent is due to the presence of dissolved salts, and that the contribution of pressure potential (or tension) to the total is not great.

A few values for the tension at the moisture equivalent are available. Moore's data[5] indicate a tension of 110 gm. cm./gm. for two soils with moisture equivalents of 18 per cent. and 25 per cent. respectively. Richards and Weaver[6] give 340 for a number of soils with moisture equivalents ranging from 22 per cent. to as low as 8 per cent. They found higher tensions than 340 for soils with a moisture equivalent of more than 22 per cent. Veihmeyer, Edlefsen and Hendrickson[9] quote a tension of about 300 for four soils with moisture equivalents between 14 per cent. and 22 per cent., and Bodman and Coleman[2] have values of 125 and 130 for two soils with moisture equivalents of 13 per cent. and 26 per cent. respectively.

Since in sandy soils the field capacity exceeds the moisture equivalent, it is to be expected that tension would be lower at the field capacity than at the moisture equivalent in such soils. Hence the low tension of 70 gm. cm./gm. found in the Winkie sand at field capacity is not inconsistent with the tensions reported for moisture equivalent.

It is not to be expected that the tension at field capacity would be of this low order for all soils. In soils of medium texture, field capacity is roughly equal to moisture equivalent, while in clays the latter is usually the greater. Consequently values for tensions similar to or exceeding those quoted for moisture equivalent are to be expected in such soils at field capacity. The lower permeability of sandy soils than of clay soils observed by Moore[5] under unsaturated conditions corresponding to tensions of about 100 gm. cm./gm., would contribute to this low tension at field capacity in a sandy soil.

Because of the low tension at field capacity in sandy soils, tensiometers should give more detailed readings within the " available " range for sandy soils than for soils of heavier texture. Stoeckler and Aarnodt[8] have noted that this is the case in dealing with the use of tensiometers in conifer nurseries. This does not mean that in sandy soils tensiometers can cover the full range of " available " water. At the maximum tension recordable (about 800 gm. cm./gm.) the water content in Winkie sand was never quite as low as the permanent wilting percentage ; but these high tensions served as a useful index of the approaching need for irrigation.

Summary.

Tension of water in a sandy soil at field capacity was found to be about 70 gm. cm./gm. (or a pressure potential of about -70×10^3 ergs/gm.).

This value is discussed in relation to published values for the pressure potential corresponding to the moisture equivalent.

Implications in regard to the use of tensiometers in the field are discussed.

Acknowledgement.

Records reviewed in this paper were kindly made available by Mr. A. G. Strickland, Chief Horticulturist, Department of Agriculture, South Australia. Tensiometers were installed and records kept by Messrs. H. K. Kemp, J. Beare and C. G. Grasby, of that Department.

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HOST PARASITE RELATIONS IN PINK ROT OF POTATO.

The symptoms of pink rot of potato tubers result from infection by *Phytophthora erythroseptica* and certain other species of *Phytophthora*, namely *P. megasperma*, *P. cryptogea* and *P. cactorum* (Cairns and Muskett[1]), and may be simulated by exposing healthy tuber tissue to such lethal substances as chloroform and toluol vapour.

The disease is characterized by a deep salmon-pink colour eventually turning black when affected tuber tissue is exposed to the air. The suggestion made by Onslow[6] and Cairns and Muskett[1] that these colour changes are due to the post-mortem oxidative reactions of cell metabolites through tyrosinase activity was confirmed by the writer, when the tyrosinase reaction was inactivated with catechol and ascorbic acid as described by Ludwig and Nelson.[4]

The outstanding feature of pink rot is that only a few species of *Phytophthora* affect the potato tissue in such a specific way as to cause these post-mortem changes. A study was therefore made of the host-parasite relations that lead to this specific effect.

The characteristic external symptoms of affected tubers are: a "rubbery" firmness, enlargement and blackening of the lenticels, and a watery exudate running from some of these lenticels. There is no evidence of any soft-rotting as in most other fungal and bacterial diseases of potato tubers. The effect of the soft-rotting type of organism is to kill the host tissue in advance of penetration, and these organisms are characterized by the production of pectinase enzyme. Chona[2] and Menon[5] have shown that *P. erythroseptica* does not produce pectinase unless grown under special conditions and even then the production of pectinase is limited.

In tubers inoculated with *P. erythroseptica* and with only a portion giving the pink reaction, slices of tissue were cut passing through both pink and non-coloured zones. When these slices were kept in closed sterile petri dishes for a few hours it was found that the pink zone was surrounded by a liquid exudate, whereas no such exudate appeared round the non-coloured zone. Other slices were placed in tap water and on removal it was found that the non-coloured zone was turgid, but the pink zone was flaccid. Vital staining with Neutral Red in 25 per cent. sucrose solution of sections cut from the pink and colourless zones showed that there was plasmolysis and acid reaction in the section from the colourless zone and no plasmolysis and an alkaline reaction in the section from the pink zone. Thus the outstanding distinction between the pink and non-coloured zones in affected tubers was that the cells in the pink zone were dead.

An examination of freehand sections stained in lacto-phenol cotton blue revealed the presence of intercellular hyphæ right up to the junction of the pink with the non-coloured zone; observations which confirm those of Pethybridge.[7] There was no evidence, therefore, that *P. erythroseptica* killed host cells in advance of penetration.

To obtain more precise information on the depth of penetration of hyphæ in relation to that of the pink zone, sections of different levels from the point of infection were plated on culture media while other comparable pieces were fixed, microtomed and studied histologically. For cultural purposes slices of tissue extending from the pink well into the colourless zone were removed aseptically and divided into $\frac{1}{4}$-inch sections. Each section was immersed in a saturated solution of calcium hypochlorite for one minute to ensure surface disinfection. Subsections of these pieces were then removed aseptically and plated on potato-dextrose-agar.

It was found, as is shown in Table I, that the fungus occurred well in advance of the pink zone, in fact it occurred within the non-coloured tissue to a distance almost equal to the depth of the pink zone. Stained microtome sections examined under

the microscope confirmed this evidence. Intercellular hyphæ were found at a similar depth as the plated pieces, though in the most recently invaded parts it appeared less dense.

TABLE I.

A Summary of the Data on the Differences between Invaded and Uninvaded Tissue in Potato Tubers Affected with Pink Rot.

	Reactions to Air.	Sections Yielding Fungus.	Inter-Cellular Mycelium.	Plasmo-lysis.	Permeability Test. Reactions of Leachates.			
					Phos-phorus.	"Nadi" Reagent.	p-Cresol.	Guaiacum.
Invaded zone.	Pink.	(6 pieces)						
		6	Abundant.	—	Deep blue.	Purple.	Orange red.	Blue.
		6	,,	—	,,	,,	,,	,,
		6	,,	—	,,	,,	,,	,,
	Colourless.	6	Abundant.	+	Pale blue.	No change.	No colour.	No colour.
		5	Moderate.	+	Pale blue.	,,	,,	,,
		3	Sparse.	+	Blue tinted.	,,	,,	,,
Uninvaded zone.	Colourless.	0	Nil.	+	No colour.	No change.	No colour.	No colour
		0	,,	+	,,	,,	,,	,,
		0	,,	+	,,	,,	,,	,,

There was no histological evidence for any difference in the relation of the fungus to the tuber cells at the junction of the pink and the non-coloured zone. The difference between the state of the host cells in pink and non-coloured zones of the invaded tissue appeared to be a physiological one ; especially since the density of the intercellular mycelium investing the cells did not appear to be any greater in the pink zone than in the zone immediately bounding it.

In order to discover whether there were physiological differences in the various zones in affected tubers, sections of tissue comparable to the levels plated were tested for permeability differences and were examined cytochemically. In testing for permeability, the respective pieces of equal size were dropped into 5 ml. of distilled water in test-tubes. After standing for half an hour at 20° C. the liquid was tested qualitatively for the presence of phosphorus (by the sulphonic-molybdate method) and oxidase enzymes (using " Nadi " reagent, p-cresol and guaiacum). The results of this examination are shown in Table I, where it will be seen that permeability of the tissue was greatest in the pink zone and least in the zone not penetrated by the fungal hyphæ as shown in the phosphorus reactions of the leachates. Over the whole pink zone all tissue was permeable. In the tissue penetrated by the fungus, but not giving the pink colour changes, permeability was greater than in the uninvaded zone. There was a gradient of decreasing permeability from the edge of the pink zone towards the border of the uninvaded zone. It is significant to note that oxidase reactions were obtained only in the leachates from the pink or dead zone. It appears that the loss of structure of the protoplast in this zone through the death of the cells allows the enzymes and other colloids normally contained to be washed out.

Cytochemical examination of freehand sections were made according to the technique of Humphrey and Dufrenoy.[3] Some sections from each level were placed in a Neutral Red solution in 24 per cent. sucrose for vital staining, other sections were immersed in a 0·01 per cent. solution of phenylenediamine chlorohydrate, and some in the sulphonic acid-molybdate reagent. Humphrey and Dufrenoy[3] found these reagents give a good composite picture of differences in permeability, behaviour of polyphenol oxidases, and distribution of phosphorous compounds in the tissues.

Examination of the tissues from the potato tuber showed that the pink zone displayed protoplasmic disorganization, gave a rapid reaction for phosphorus, and represented non-living host tissue. In the living part of the tuber penetrated by the fungus, there was a gradient in the intensity of the phosphorus reactions and in the presence of quinones as vacuolar secretions. The reactions were most marked near the margin of the pink or dead zone and tailed off towards the beginning of the uninvaded zone. Humphrey and Dufrenoy interpret the release of phosphorous compounds, vacuolar secretions and the presence of quinones as evidence for decompensated respiration. Interpreted in the same way the reactions obtained in the living part of the potato tuber penetrated by the fungus afford evidence of a gradient of decompensated respiration from the margin of the pink or dead zone to the beginning of the uninvaded zone.

The presence of *P. erythroseptica* in the intercellular spaces of the potato tissue causes an increase in permeability and decompensated respiration in the cells. These effects apparently increase in severity until a threshold value is reached when the cells collapse.

In an attempt to reproduce these changes with metabolites of *P. erythroseptica*, the fungus was grown on various liquid synthetic media containing potato extract. At various stages of growth, fresh potato discs were immersed in the filtered substrate and examined cytochemically, but at no time was any effect noted. Again the liquid from the pink zone of inoculated tubers was extracted and potato discs immersed in the liquid obtained but no reaction was obtained.

Conclusions.

From these investigations it will be seen that in a potato tuber that is partly invaded by *P. erythroseptica* three distinct zones may be recognized.

These are : a zone of living uninvaded tissue, a zone of invaded but living tissue in which the fungus behaves as a true parasite, and a zone of invaded but dead tissue that gives a characteristic pink coloration when exposed to oxygen, and in which the fungus lives on as a saprophyte.

The colour changes in the dead zone are due to the tyrosinase reaction which is a post-mortem oxidase reaction resulting from the mixing of cell metabolites in the presence of oxygen.

When *P. erythroseptica* invades the tuber tissue the presence of the intercellular mycelium increases the permeability of the host cells and causes a degradation of the phosphorylated compounds leading to decompensated respiration and finally the death of the invaded tissue. However, the mechanism through which the fungus alters the permeability of the cells remains unknown.

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The Australian Institute of Agricultural Science

EIGHTH GENERAL MEETING.

The eighth general meeting will be held at Science House, Gloucester Street, Sydney, on 8th March, 1946, at 7.30 p.m.

The meeting will be of a *pro forma* nature and the business will include the report of Council for the preceding period ; the statement of accounts and balance sheet ; and the report of Council concerning the election of President.

F. T. Bowman,
Hon. General Secretary.

MEETINGS OF COUNCIL.

Meetings of Council were held on 7th August and 2nd October, when all Branches were represented. Reports revealing the steps taken by Branches to circulate the Institute's statement on the salaries of scientific agricultural personnel among appropriate authorities were received. A sub-committee set up to deal with Institute publicity submitted a statement, which was adopted. In this statement it was pointed out that since Branches maintain the Institute's activities, Branch committees should see that satisfactory reports of such activity reach people who are likely to be interested. The expression of " Institute opinion ", on the other hand, was a responsibility of Council, and to meet this need a Publicity Committee was proposed. Such a committee, with Mr. G. de V. Davis as convener, Dr. H. J. Hynes and the Hon. General Secretary, Dr. F. T. Bowman, was constituted.

By-laws governing procedure for the election of the President have been adopted and progress on the preparation of draft rules for the conduct of general meetings reported.

Reports were received concerning enquiries on the prospects for establishing an Australian Journal of Agricultural Science ; investigations are continuing.

The subject of an Australian agricultural policy and matters related thereto was keenly debated at the last general meeting of the Institute and the Council has had a long and stern task in grappling with its legacy ; the need for a clear statement of Institute opinion on this important matter. Strenuous efforts are being made to clear up the matter.

An exceptionally large draft of new members, corporate and student, was admitted on the recommendation of the Qualifications Committee.

Corporate Membership.

	Branch.		Branch.		Branch.
Jarrett, F. G. ..	N.S.W.	Eagle, Esther M.	N.S.W.	Raymond, F. H.	Vic.
Phillips, G. P.	,,	McKenzie, D. J.	,,	Stewart, Irene J.	,,
Sutherland, J. R.	,,	Kingsland, Alison M.	,,	Thomas, Margaret P.	S.A.
Stack, J. N. ..	,,	Waring, E. J. ..	,,	Mertin, J. V. ..	,,
Wagner, V. J. ..	,,	Clowes, G. J. ..	,,	Tiver, N. S. ..	,,
Cassidy, N. G. ..	,,	Salton, M. R. J.	,,	Hunter, J. S. ..	Q.
Fitzpatrick, J. T.	,,	Debrett, P. H. ..	Vic.	Clothier, A. L. ..	,,
Myers, L. F. ..	,,	Newman, R. J. ..	,,	Parker, Joan C...	W.A.
Jardine, R. ..	,,	Hexter, G. W. ..	,,		

Student Membership.

	Branch.		Branch.		Branch.
Lea, H. W. ..	N.S.W.	Conroy, R. J. ..	N.S.W.	Coombe, B. G. ..	S.A.
Smith, G. J. F. ..	,,	Bridgland, L. A.	,,	Harvey, R. G. M.	,,
Purchase, Hilary F.	,,	Fogl, E. R. ..	,,	Moore, A. W. ..	,,
Beattie, A. W. ..	,,	Mullen, M. ..	,,	Cant, R. R. ..	,,
Davis, R. S. ..	,,	Dickson, W. R.	Vic.	Parkes, Shirley ..	W.A.
Wyndham, Lucinda M. ..	,,	Mackie, W. B. C.	,,	McNeill, N. ..	,,
Charles, A. W. ..	,,	Krause, M. R. ..	S.A.	Williams, V. J. ..	,,
Gellatley, J. G. ..	,,	Harris, W. B. ..	,,	Neil, G. H. ..	,,
Long, J. K. ..	,,	Potter, J. C. ..	,,	Hare, R. ..	,,

The large numbers seeking admission to membership have attracted attention to the delays imposed by present procedures. To reduce such delays, Branches in future are asked to forward applications directly to the Qualifications Committee.

MEETINGS OF BRANCHES.

Victorian Branch.

A joint meeting of the Victorian Branch and the Melbourne University Agricultural Society was held on 25th September, when Professor Wadham and Mr. G. W. Leeper spoke on " Agro-climatic Features of Northern Australia, with particular reference to the Ord River Project ".

The Branch held a special general meeting on 12th October to discuss formation of a Council of Scientific Societies for Victoria (see Current Notes and News), and the A.I.A.S. Council proposals for implementation of an all-Australian agricultural policy. The meeting agreed that there was room for an enlarged Commonwealth department to deal with agriculture in peace time, and appointed a sub-committee to bring before a further Branch meeting amendments to the document sent to Branches by Council.

South Australian Branch.

A general meeting of the Branch was held on 24th August, when Drs. E. G. Hallsworth and A. R. Callaghan spoke on " Regional Research Stations ". A large number of visitors from the Winter School in Soil Science attended the meeting. Dr. Hallsworth described two types of stations : one to deal with single specific problems, and the other to deal with all the problems affecting primary production in the region. After outlining the facilities and equipment necessary for these stations, Dr. Hallsworth referred to the problems of personnel, particularly the need for periodical study leave for workers stationed at isolated centres. The regional laboratories might well be governed by a body having representation from the central and regional stations and from the local district itself.

Dr. Callaghan described the organization of research stations in the United States of America and indicated how necessary it was for regional stations to be planned on a national basis. At present the dissemination of knowledge from research workers to the producers through extension workers was far too slow and there was an urgent need for a speeding up of this process. This required a greater understanding between research and extension officers and a full appreciation of each other's difficulties. In South Australia regional stations were needed for cereal breeding, animal production problems, the breeding of pasture plants and pasture experimentation, investigation into farm management problems and economics, soil and fodder conservation and many other problems of a local nature.

On 21st September a general meeting was addressed by Mr. D. Scott Thompson and Mr. P. G. Schinckel. Mr. Thompson surveyed " The Lamb Raising Industry of South Australia and Some of its Problems ". Mr. Schinckel spoke on " Animal Breeding and Livestock Improvement ". Points in this address are referred to among the items on current news and views in this issue.

At a third meeting on 23rd November addresses were given by Messrs. P. G. Schinckel and V. R. McDonald. Speaking on the subject of seasonal variation in livestock production, Mr. Schinckel drew attention to variations in the bulk and composition of pastures at different times of the year.

A fine diagram, based on data secured at the Waite Institute, was used to illustrate the seasonal variation in pasture, especially in respect to its protein content.

A diagram was also shown to illustrate milk production during a " normal " lactation cycle and the variations which experience at Roseworthy had shown occur as the result of cows " coming in " during different quarters of the year. Further graphs to illustrate the percentage of " cows in milk " and milk production month by month in three districts of South Australia were also shown.

It was suggested that seasonal variation in the quality of pasture as indicated by its protein content was an important element in maintaining milk production. Mr. Schinckel also dealt briefly with similar problems in sheep where changes in the live weight of sheep and in the wool staple could be associated with seasonal variation of pastures.

Mr. MacDonald's address on " Some Modern Trends in the Dairying Industry ", which provoked a lot of discussion, will be found on p. 166.

Queensland Branch.

A meeting of the Queensland Branch on 13th September was addressed by Mr. J. F. F. Reid, on the subject of agricultural journalism. The speaker has been Editor of the Agriculture and Stock Department's Journal for the last 24 years, and his address gave rise to a considerable amount of discussion. It was apparent that members in general are quite concerned with the publicity which should be given to research work. In common with the other States, Queensland has the problem of presenting findings in a form which will be assimilated by the maximum number of agricultural producers.

Western Australian Branch.

On the 20th August Dr. B. T. Dickson, the Federal President of the Institute, addressed a general meeting of the Western Australian Branch on " The Need for a Commonwealth Department of Agriculture and its Relation with State Departments of Agriculture ". A number of the

visiting senior officers of C.S.I.R. were present, and a special welcome was extended to Dr. A. E. V. Richardson, foundation Federal President, and to Mr. A. J. Vasey, who was General Secretary for the first ten years of the Institute's life.

Dr. Dickson drew attention to the fluctuations which kept recurring between States of plenty and dearth, especially since the first world war. During World War II food production again became vital, with shortage of manpower and materials to hinder speedy and sufficient production. In the war-time organization of agriculture, no less than a dozen Commonwealth departments and sub-departments were responsible for one phase or another. It seemed desirable that a properly constituted Commonwealth Department of Agriculture should take over these responsibilities to obtain maximum efficiency. In co-operation with State Departments of Agriculture it would plan for Australia. With international agriculture in the hands of the United Nations Food and Agriculture Council, representative of 22 nations, it would provide a connexion between this body and States in the matter of planned production.

In the subsequent discussion Dr. Richardson remarked that the functions required of the suggested department were practically covered by the Agricultural Council and the Department of Commerce and Agriculture. Extension and agricultural education needed enlarging and a thorough system of decentralization maintained as agriculture was very localized.

Australian Capital Territory Branch.

Two interesting meetings of the Australian Capital Territory Branch have been held since 30th June, the first on 11th July, when the main business took the form of an address by Colonel J. K. Murray, Professor of Agriculture, University of Queensland. Colonel Murray took " Agriculture in the Mandated Territories " for his subject and presented members with a very interesting and vivid picture of the nature and position of agriculture in these areas. The most important need, Colonel Murray said, in the agriculture of the mandated territories was for an improvement of the native gardens, and not in an extension of European plantation crop establishment. As part of the improvement of native agriculture, there was need for attention, particularly in the direction of animal husbandry and the introduction of ordinary cattle and sheep to the highlands, and probably zebu cross types of cattle for the coastal lowland conditions.

The second meeting was held on Wednesday, 10th October, when Mr. J. H. Shaw, of the Regional Planning Division of the Department of Post-War Reconstruction, gave an address on " The Regional Approach ". The speaker stated that the importance of regions to a particular nation is now realized to a greater degree than was previously the case. There is a world-wide movement looking to regionalism to help solve its problems. This movement has come largely from the desire to counteract the trend towards centralization in politics, in administration and in industry, which, over the last half century, had become more pronounced. The regionalist claims that local policies should be shaped locally, and that the man on the spot is better able to work out purely local problems than State or central departments. There are two main aspects of regionalism: regional administration and regional planning, both closely allied, working through the principle of unified development of resources.

Tasmanian Branch.

At the general meeting held at Nutgrove Crescent, Sandy Bay, the question of an agricultural science course in Tasmania was discussed. The subject was introduced by Mr. N. H. White, who submitted a curriculum designed to fit in with present university courses in biological subjects.

After an exhaustive discussion, it was agreed that the time was not propitious to establish a Faculty in Agriculture, but if this was done a Chair of Agriculture should be instituted. Meanwhile, students desiring to take up such a course should be subsidized at a recognized Australian university.

Current Notes and News

Council of Scientific Societies for Victoria.

Since 10th April last, delegates from the Victorian branches of some 25 scientific and technological societies have been investigating a proposal, made at a Planning of Science Conference held in Melbourne in June, 1944, to form a National Council of Scientific Societies. The Victorian branch of the A.I.A.S. has been represented on this committee.

At their fourth meeting on 11th September, delegates passed a resolution recommending to their parent bodies that a council embracing scientific societies in Victoria be formed and a draft constitution was framed. Notice of resolution and a copy of the provisional constitution were sent to all societies in Victoria likely to be interested, with a request that each send a representative, with power to vote, to an inaugural meeting on 27th November.

At a special general meeting of the Victorian Branch of the A.I.A.S. held on 12th October, a report from its delegate, Mr. R. A. Boyle, was received and the meeting resolved that " the Victorian Branch endorse the recommendation of the investigational committee to set up in Victoria a Council of Scientific Societies ". Mr. Boyle was elected delegate to further conferences.

According to the provisional constitution, the main objects of the Council shall be to promote a closer liaison between scientific societies and to establish contact between the societies and the general public. These objects conform closely to those of a Council of Scientific Societies already in existence in Tasmania.

It is suggested that the Council might also concern itself with some or all of the following : (1) organization of conferences ; (2) press and radio publicity for science ; (3) improvement of facilities for training of scientists and technicians ; (4) co-ordination of professional activities on such matters as regional planning ; (5) setting up of scientific and professional libraries ; (6) setting up of an appointments bureau ; and (7) provision of buildings to house scientific and technical societies.

It was realized by the investigational committee that the objects of such a council might, to some extent, overlap those of other bodies, and in particular those of the A.N.Z.A.A.S. It was indeed obvious that the proposed council might be well and conveniently hatched beneath the wings of such an august and long-established body. The constitution of the A.N.Z.A.A.S. was examined and a clause found which, it was thought, might be interpreted in such a way as to permit of this desirable result.

A ruling was sought from the Hon. General Secretary of the Association. This indicated that the question was one for the General Council of the Association, which might not take place until August, 1946, and that it would be necessary to set out clearly the purpose of the proposed council. It was decided, therefore, to recommend a modest beginning and perhaps consider affiliation later in the light of some maturity.

Livestock Improvement.

At the September meeting of the South Australian Branch, Mr. P. G. Schinckel, Senior Lecturer in Animal Husbandry at Roseworthy Agricultural College, gave members an interesting address on livestock improvement. Mr. Schinckel said that the average productivity of sheep and dairy cattle in Australia has made only limited advances during the last 25 years. An examination of the wool production figures for South Australia for the period 1915 to 1940 reveals that the average fleece cut by South Australian sheep during this period has increased by about ¾ lb.—a rather small increase when one considers the efforts expended by breeders to improve the productivity of their flocks. The dairy production figures available make it difficult to assess what improvement has actually taken place, although an examination of overseas figures would not encourage us to believe that any substantial improvement has been achieved. An analysis by the New Zealand Dairy Board (1943) of herd production figures in that country revealed that between 1919-20 and 1942 the average butter fat production per cow was raised about 61 lb. This total was apportioned as follows :

Improvement from selection of daughters of highest producing dams ..	2 lb.
Improvement from elimination of low producers	8 lb.
Improvement from change in breed composition	16 lb.
Improvement from better nutrition, use of improved stock and from other unknown factors	35 lb.

Further interesting details are revealed in the 1941-42 Annual Report of the New Zealand Dairy Board, with respect to the productivity of the daughters of 1,078 bulls. Thirty-two per cent. of bulls improved production, 31 per cent. maintained production, and 37 per cent. lowered production. The net result was that the progeny barely maintained the production of their dams. Similar findings have also been recorded from America, where it was found that the 29,570 daughters of 4,302 bulls average 451 lb., while their dams averaged 452 lb.

These findings appear to indicate that commonly adopted methods of livestock breeding are doing little to raise the genetic merit of commercial flocks.

Mr. Schinckel then spoke on the heritability of animal characters and methods of livestock breeding employed at present. He laid great stress on the value of progeny testing as an aid to more accurate selection of the best breeding material. The value of different mating systems ; inbreeding, outbreeding, crossbreeding and corrective mating were each discussed briefly. Looking to the future, Mr. Schinckel thought that the following outstanding developments in the past pointed the way :

(1) The results of progeny testing swine in Denmark and sire survey work in America and New Zealand.

(2) The development of inbred lines for the production of commercial sires as is being developed in American swine.

(3) The development of artificial insemination in order to take fullest advantage of outstanding sires.

A fourth development possible is the breeding of strains of animals especially adapted to a particular environment. This development has already taken place to some extent in the merino flocks of Australia, but there is room for considerable investigation into the exact relationship between physiology of production and environment.

Pest Destroyers Act, N.S.W.

The Pest Destroyers Act, which came into operation in New South Wales from 1st September, regulates the sale of and prevents the adulteration of all pest destroyers, including insecticides, fungicides and weed destroyers, and provides for the registration of all pest destroyers of approved composition. This legislation brings New South Wales into line with other States in which similar Acts have been in force for some years.

Visit of Senior Officers of the C.S.I.R. to Western Australia.

Towards the end of August several senior members of the C.S.I.R. visited Western Australia to confer with the State Committee of the C.S.I.R., and with officers of State Government Departments and the University, on the subject of co-operation in research activities. The visitors included Drs. A. E. V. Richardson, B. T. Dickson, A. J. Nicholson, L. B. Bull, I. W. Wark and Messrs. H. Marston, G. A. Cook and A. J. Vasey.

Book Reviews

THE EARTH—OUR MOTHER,
by B. A. Santamaria, B.A., LL.B.

(*Pp.* 192. *Araluen Publishing Company, Melbourne. Price* 10s.)

This is a Back-to-the-Land book, written by an active member of the National Catholic Rural Movement. The argument is that Australia must increase its population rapidly; that birth-rates all over the world are higher on farms than in cities; and that we must accordingly increase the proportion of people living on the land. Further, commercial farmers (a group including the great majority of Australian farmers) do not raise very large families, and therefore we must have small, nearly self-contained farms, which in America appear to produce the biggest families. While Mr. Santamaria thus makes population the main theme, he also considers that community life is better where farms are self-contained than where they are commercial. He puts these arguments above economic considerations and so writes in favour of a complete change in our agriculture and thereby joins issue against the Rural Reconstruction Commission with its view of farming as an industry.

This seems a tenable attitude for those whose preferences lie that way, but after giving lengthy reasons for rejecting economics, Mr. Santamaria goes on to argue valiantly that the small independent farm (as he calls it) is actually more efficient than the larger mechanized farm. As might be expected, this section of the book is not a success. A sample of the method is given: In order to show that Russian farming has not gained in efficiency by collectivization and mechanization, one Hubbard is quoted to the effect that it is true that the peasants can now, for the first time, buy watches and bicycles, but that this doesn't count, *because they are so cheap now!*

The book covers other fields, particularly debt, tenure, and farmers' co-operatives. In this last field Mr. Santamaria is at his best, since he is recounting his own encouraging experiences with pioneer co-operatives in Victoria.

The initial assumption that Australia needs a large population is the one that most needs challenging. I have never seen any reason given for believing that we would be happier, wealthier, or better in any way if there were, say, 12 million Australians instead of 7½. In any case we could not compete with the colossal birth-rate of Asia, nor should we try to. The experience of Asiatic countries shows that numbers give no security against invasion; it is machines, and most of all Plutonium factories, that count. Finally, it should be pointed out that, granting all that Mr. Santamaria says in praise of the rural life of Scandinavia, the birth-rate of those countries is well below that of Australia.

G. W. Leeper.

PRINCIPLES OF ANIMAL PRODUCTION,
by C. P. McMeekan and others.

(*Whitcombe and Tombs. Price* 14*s.* 6*d.*)

Everyone interested in animal production, whether scientist, student, farmer or stockman will be grateful to Dr. C. P. McMeekan and his collaborators for compiling this book which presents in language the layman can follow the principles basic to animal production.

The book is divided into four parts; one dealing with reproduction and lactation of farm animals, one with growth and development, one with nutrition and one with breeding. It is attractively printed on good paper and is liberally illustrated with photographs and diagrams. It is not published for personal profit—the royalties from the sale of this book go to assist the training of young men in animal production.

The authors are to be congratulated on producing the book. Its publication is most opportune. In recent years, largely as a result of the stimulus given by Dr. John Hammond, a great deal has been done to elucidate and establish the principles of growth and development and the physiology of lactation and reproduction that are basic to animal industry. Moreover, Dr. A. L. Hagedoorn by the publication of his book "Animal Breeding" has done a great deal to

stimulate a more rational and scientific approach to animal breeding. Yet it is all too apparent to those abreast of the scientific developments in the field of animal production, how far behind them are current practices and popular thinking. In mobilizing the essentials of the newer knowledge into one volume, Dr. McMeekan and his associates not only satisfy a long-felt need but succeed admirably in their aim " to teach the animal husbandman of tomorrow to think about the great job ahead of him—and to help change the business of animal production from an empirical art to an exact science ".

The parts dealing with reproduction, lactation and growth gain strength from the special interest and work of Dr. McMeekan in this field of knowledge and from the New Zealand experience of the authors. The part on nutrition introduces two very good chapters, one on the efficiency of farm animals as elaborators of human food and the other on pastures as a basic food for livestock—an aspect of nutrition frequently given scant attention. From the Australian point of view where the most important animal is the sheep and the characteristic pasture is extensive and ephemeral, one would have liked to see the recently elucidated principles governing sheep nutrition and drought feeding incorporated into such a book as this. As it is, one feels that the mere recapitulation of elements of nutrition, and the failure to include a chapter on the nutrition of ruminants leaves this part of the book weaker than it might have been. The part dealing with breeding is a commendably clear exposition of the main principles involved and their implications.

The book will be valuable not only to students of animal production, but also farmers and stockmen generally. It deserves a wide circulation.

A. M. Stewart.

THE SEMEN OF ANIMALS AND ITS USE FOR ARTIFICIAL INSEMINATION, by James Anderson, B.Sc., Ph.D., M.R.C.V.S.

(*Imperial Bureau of Animal Breeding and Genetics, Technical Communication. Pp.* 151. 1945. *Price 7s. 6d. sterling.*)

While the literature contains a large volume of data on the semen of animals and artificial insemination, the last comprehensive review in this field of animal production was that of the Imperial Bureau of Animal Genetics published in 1933. It is therefore appropriate that this voluminous but widely scattered literature should have been collected into a single comprehensive summary by such an authority as Dr. J. Anderson, of the Kenya Veterinary Services.

The main text is presented in three parts and covers the literature up to 1943. Subsequent information is given in a supplement. " Part I is directed particularly to the need of the scientific worker for a detailed review of the literature dealing with the study of semen, the factors which affect its production, and the properties and reactions which affect its use for insemination. Part II embraces a discussion of the use of artificial insemination in the different species, of its application in different countries and circumstances, and of the limitations imposed on its use by various factors, including those arising from the physiological processes of female reproduction. Part III describes the actual techniques of semen collection, examination and handling, and of insemination ; it is thus the section of most direct interest to those concerned with the practical application of the method."

In addition to covering all aspects of semen physiology and artificial insemination, this publication contains considerable information on the physiology of reproduction. It is not only of interest to the veterinary surgeon but also to the field worker in animal production.

P. G. Schinckel.

PLANTS AND PLANT SCIENCE IN LATIN AMERICA. Edited by Frans Verdoorn.

(*The Chronica Botanica Co., Waltham, Mass. Melbourne Agents, N. H. Seward Ltd. Price 6 dollars.*)

The modest aim set forth in the Editorial is more than realized, and for those who contemplate collecting or conducting research into the Latin American plants this work would be invaluable. To attempt to cover the whole field of pure and applied botanical enquiry for an area of some 7,830,000 square miles—nearly thrice that of Australia, and with far greater floral diversity—and the hundred scattered references involved might well appear vainly ambitious, but Verdoorn has succeeded in what must surely be one of the most comprehensive scientific symposia. A galaxy of brilliant systematists and research workers has contributed material to this splendid book.

There are valuable sections on geology, climate, soil, agriculture, plant pathology, plant breeding and plant geography with many explanatory text maps. Dr. Carl Skottsberg, whose writings on antarctic vegetation are familiar to the Australian ecologist, has contributed neat and informative essays on the plant life of Juan Fernandez and Falkland Islands.

Introductory chapters give a most extensive list of travel and guide books arranged alphabetically according to authors while the volume concludes with a special supplement in which are listed the Plant Science Institutions, Stations, Museums, Gardens and Societies in Central and South America and the West Indies.

Criticism of such a compendium would seem impertinent, but one could wish that the headings of subject matters had been accentuated by means of distinctive, bolder type and that wider spacing had been used between the articles, which appear to run on into each other without noticeable break in type. Otherwise the general set-up, printing and strong binding leave little to be desired.

Space forbids a review of every section, but those devoted to soil conservation, economic plants, location of botanical collections, rubber culture and plant breeding deserve special mention on account of their economic importance in present-day world affairs.

A. W. JESSEP.

Personal Notes

Colonel J. K. Murray, a past President of the Queensland Branch of the Institute, formerly Professor of Agriculture in the University of Queensland and Principal of the Queensland Agricultural High School and College, has been appointed Administrator in the Provisional Administration of the Territories of New Guinea and Papua.

Dr. R. J. Noble left Sydney early in October for Quebec as leader of the Australian delegation to the conference of the United Nations Food and Agricultural Organization.

R. H. Anderson has been appointed to the position of Curator of the Sydney Botanic Gardens and National Herbarium.

Capt. A. H. Bishop, 2/2nd Pioneers, the Victorian Branch's only P.O.W. in Japanese hands, has returned to Victoria. Friends had an opportunity to welcome him at the M.U.A.S. "At Home", which was revived this year and attended by many A.I.A.S. members. Capt. Bishop was on the staff of the Shell Co. before enlisting.

The following Victorian Branch members have been released from the services to take up civil occupations:

Group Capt. J. P. Ryland, D.F.C.

Major P. Lang (Department of Post-War Reconstruction—seconded to Rural Reconstruction Commission).

E. T. Beruldsen (Deputy Co-ordinator, Rural Training, with the Department of Agriculture).

G. B. Woodgate, formerly Principal Dookie Agricultural College, Victoria, has been appointed to the new position of Superintendent of Agricultural Education in the Victorian Department of Agriculture.

E. E. Henty is engaged in pastoral pursuits on his own account since his resignation from the Victorian Department of Agriculture.

F./Lt. A. L. Tisdall has been discharged from the R.A.A.F. and has taken up duties under the Division of Plant Industry, C.S.I.R. at the New Regional Research Station, Deniliquin, N.S.W. Mr. Tisdall was formerly at Merbein.

P. J. Skerman has taken up duties as agricultural resources officer in the Queensland Bureau of Investigation under the Land and Water Resources Development Act. A. F. Bell has been appointed Deputy Chairman of the same bureau.

W. M. Willoughby recently transferred from Canberra to the Agrostology Section at the C.S.I.R. Regional Laboratory, Deniliquin, New South Wales.

G. A. H. Helson visited army farms in the Northern Territory in July to make a survey of the insect pests affecting vegetable crops and to carry out experiments with D.D.T.

C. S. Christian has been visiting Western Australia looking into pasture problems there. While in the west, he visited the Ord River Experimental Station and went from there to the Army Experimental Farm at Katherine, Northern Territory.

Dr. W. V. Ludbrook has been demobilized from the R.A.A.F., and has resumed duty with the Division of Plant Industry, Canberra.

Milton Moore has been demobilized from the R.A.A.F. and has rejoined the Agrostology Section of Plant Industry, Canberra.

D. Norris visited Camooweal, where he investigated the problem of puffballs which were destroying the surface of the aerodrome there.

Lieut. T. J. Robinson, R.A.N.V.R., has recently returned to the Animal Nutrition Branch of the Western Australian Department of Agriculture after four years' naval service. During that period he saw service in the East Indies, Persian Gulf and Pacific zones.

Professor G. A. Currie and R. P. Roberts have returned to Perth from the eastern States after having reported to the Ministry of Post-War Reconstruction on the organization throughout Australia of agricultural training of ex-servicemen desiring to go on the land.

Len Miller, who underwent an operation for appendicitis recently, has resumed his work as Entomologist with the Department of Agriculture.

R. A. Sherwin, who has been attached to the Department of Agriculture, Tasmania, for over fifteen years and has been a member of the Tasmanian Branch of the A.I.A.S. since its inauguration, has resigned to take up business in Glen Innes, New South Wales.